Mead

COMPOSITION

LOGBOOK #59

START: 20 OCT 1999 JD: 2451471.7

END: 07 DEC 1999 JD: 2451520.4

152 sheets • 304 pages

$9\frac{3}{4}$ x $7\frac{1}{2}$ in/24.7 x 19.0 cm

wide ruled • 09710 2451520.4

scientia est potentia

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Mead

SQUARE DEAL

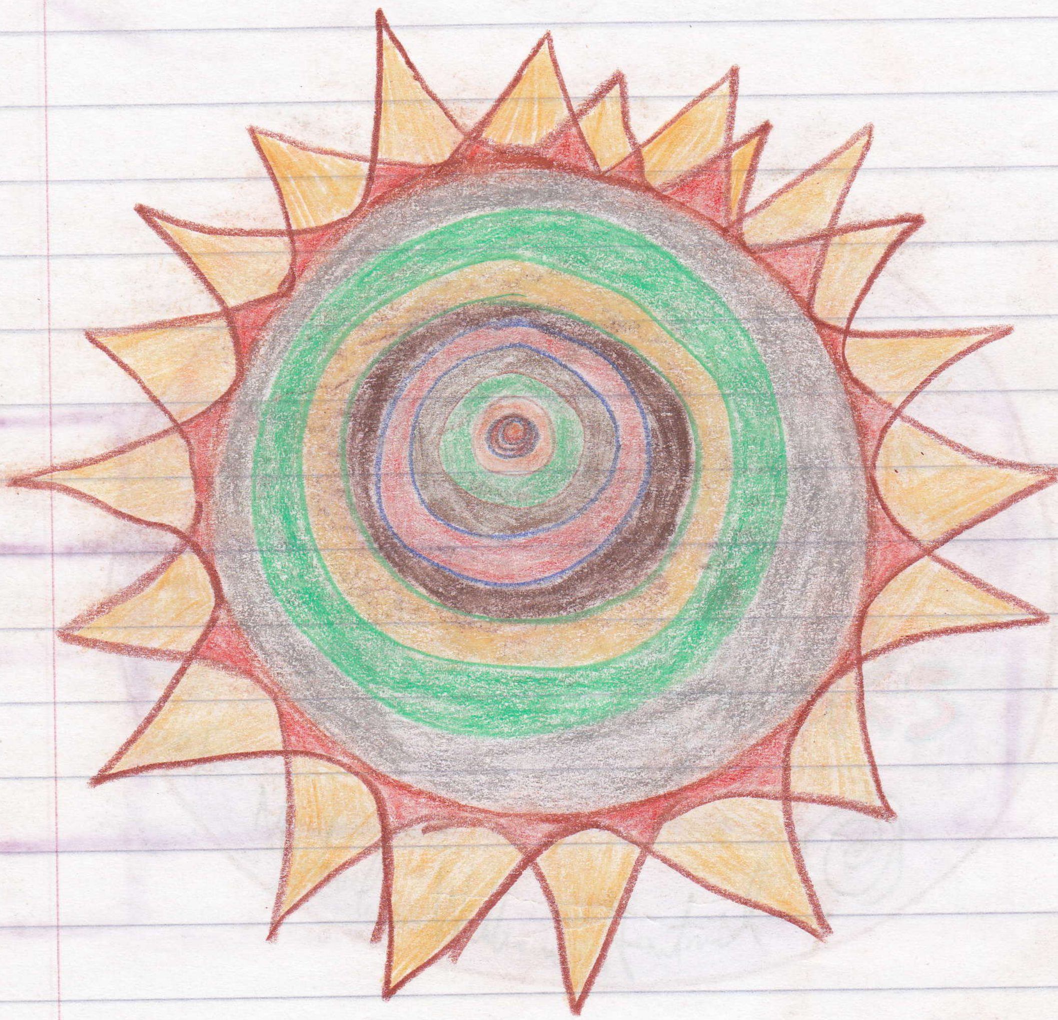
CLASS PROGRAM

NAME LOGBOOK #59 ADDRESS

SCHOOL Scientia est Potentia CLASS

TIME FROM / TO...		PERIOD 1	PERIOD 2	PERIOD 3	PERIOD 4	PERIOD 5	PERIOD 6	PERIOD 7	PERIOD 8	Gregorian date
MONDAY	SUBJECT	START: Julian Day								
	ROOM / INSTRUCTOR	2451471.7								20 OCT 1999
TUESDAY	SUBJECT / ROOM / INSTRUCTOR	END: Julian Day								
WEDNESDAY	SUBJECT / ROOM / INSTRUCTOR	2451520.5								07 DEC 1999
THURSDAY	SUBJECT / ROOM / INSTRUCTOR									
FRIDAY	SUBJECT / ROOM / INSTRUCTOR									
SATURDAY	SUBJECT / ROOM / INSTRUCTOR									

Michael William Hentusch 1967 -



LOGBOOK # 59

Scientia est Potentia

Greek symbols

α	alpha	ν	nu
β	beta	ξ	xi
γ	gamma	o	omicron
δ	delta Δ	π	pi
ϵ	epsilon	ρ	rho
ζ	zeta	σ	sigma
η	eta	τ	tau
θ	theta	υ	upsilon
ι	iota	φ	phi
κ	kappa	χ	chi
λ	lambda	ψ	psi
μ	mu	ω	omega

$\frac{d}{dx} \ln(x) = \frac{1}{x}$ very well, what about $\int \ln(x)\,dx$?

$\int \ln(x)\,dx$ Here we use integration by parts.

$\int u\,dv = uv - \int v\,du$

let $u = \ln x$, $dv = dx$, $du = \frac{1}{x}dx$

and $v = \int dv = \int dx = x$

Substituting, we obtain $\int \ln(x)\,dx =$

$$(\ln(x))x - \int \frac{x}{x}dx$$

$$= x \ln x - x + C$$

What about $\int \frac{\ln(x)}{x}\,dx$?

let $u = \ln(x)$
then $du = \frac{1}{x}\,dx$

$$\int u\,du = \frac{u^2}{2} + C$$

substituting, $\int \frac{\ln(x)}{x}\,dx = \frac{\ln(x)^2}{2} + C$

BASICS

DERIVATIVE FORMULAS

1. $\frac{d}{dx}(c) = 0$
2. $\frac{d}{dx}(x) = 1$
3. $\frac{d}{dx}(cu) = c\frac{du}{dx}$
4. $\frac{d}{dx}(u+v-w) = \frac{du}{dx} + \frac{dv}{dx} - \frac{dw}{dx}$
5. $\frac{d}{dx}(uv) = u\frac{dv}{dx} + v\frac{du}{dx}$
6. $\frac{d}{dx}\left(\frac{u}{v}\right) = \frac{v\frac{du}{dx} - u\frac{dv}{dx}}{v^2}$
7. $\frac{d}{dx}(u^n) = nu^{n-1}\frac{du}{dx}$
8. $\frac{d}{dx}(uvw) = uv\frac{dw}{dx} + uw\frac{dv}{dx} + vw\frac{du}{dx}$

9. $\frac{d}{dx}(\sqrt{u}) = \frac{d}{dx}(u^{1/2}) = \frac{u^{-1/2}}{2}\frac{du}{dx}$ OR $= \frac{1}{2\sqrt{u}}\frac{du}{dx}$

10. $\frac{d}{dx}\left(\frac{1}{u}\right) = \frac{d}{dx}(u^{-1}) = -\frac{1}{u^2}\frac{du}{dx}$

11. $\frac{d}{dx}(\ln(u)) = \frac{1}{u}\frac{du}{dx}$

12. $\frac{d}{dx}(\log_a u) = \frac{1}{\ln(a)} \cdot \frac{1}{u}\frac{du}{dx}$

13. $\frac{d}{dx}\sin u = \cos u \frac{du}{dx}$

14. $\frac{d}{dx}\cos u = -\sin u \frac{du}{dx}$

15. $\frac{d}{dx}\tan u = \sec^2 u \frac{du}{dx}$

16. $\frac{d}{dx}\cot u = -\csc^2 u \frac{du}{dx}$

17. $\frac{d}{dx}\sec u = \sec u \tan u \frac{du}{dx}$

18. $\frac{d}{dx}\csc u = -\csc u \cot u \frac{du}{dx}$

ε

BASIC FORMS OF INTEGRALS

1. $\int u\,dv = uv - \int v\,du$

2. $\int u^n du = \frac{1}{n+1} u^{n+1} + C \quad , \quad n \neq -1$

3. $\int \frac{1}{u} du = \ln(u) + C$

4. $\int e^u du = e^u + C$

5. $\int \sin u\,du = -\cos u + C$ D13 D14

6. $\int \cos u\,du = \sin u + C$ D13

7. $\int \sec^2 u\,du = \tan u + C$ D15

Note! let us pause here and refer to a booklet such as INTEGRALS AND MATHEMATICAL FORMULAS for the more complicated integrals. The ones listed herein, I would like to commit to memory.

Method of Substitution

Notes From Brainwaves_ Ø
Jan 1995 → Sept 1999

1. let $u = f(x)$ when $f(x)$ is raised to a power
   when $f(x)$ appears in the denominator
   when $g(f(x))$ - it appears as an inside function of a composition.

2. compute $du = f'(x)\,dx$
3. substitute u for $f(x)$ and du for $f'(x)\,dx$ in the integrand
4. Integrate and substitute $f(x)$ back for u
   add constant
5. check solution by differentiating and comparing to the original integrand.

Two Options

① Carry out method of substitution
compute the difference of values at $x=b$ and $x=a$

② After making the substitutions for $u = f(x)$ and $du = f'(x)\,dx$, also substitute for the limits of integration: $u = f(a)$ when $x = a$
$u = f(b)$ when $x = b$

The two options are shown (see p. 6)

option 1

$$\int_1^2 \frac{x}{(x^2+3)^3}\,dx$$

let $u = (x^2+3)$

let $du = 2x\,dx$

$(x^2+3) \rightarrow u \qquad x_{dx} \rightarrow \frac{du}{2}$

hence,

$$\int \frac{x}{(x^2+3)^3}\,dx = \int \frac{du}{2\;u^3}$$

$$\int \frac{du}{2u^3} = \frac{1}{2}\int u^{-3}\,du = \frac{1}{2}\left(\frac{u^{-2}}{-2}\right) = -\frac{u^{-2}}{4}$$

$$-\frac{u^{-2}}{4} = -\frac{1}{4u^2} = \frac{-1}{4(x^2+3)^2}$$

$$\int_1^2 \frac{x}{(x^2+3)^3}\,dx = \frac{-1}{4(x^2+3)^2}\Bigg]_{x=1}^{x=2} = \frac{-1}{196} - \frac{-1}{64} = \frac{33}{3136}$$

option 2 let $u = x^2+3$ and $du = 2x\,dx$

when $x=1$, $u=4$ when $x=2$, $u=7$

$$\int_1^2 \frac{x}{(x^2+3)^3}\,dx = \int_4^7 \frac{du}{2(u)^3} = \frac{-1}{4u^2}\Bigg]_{u=4}^{u=7} = \frac{33}{3136}$$

remember this : $\frac{d}{dx}\ln(x) = \frac{1}{x} \qquad \int x^{-1}\,dx = \ln(x)$

$\int (5x-1)^4\,dx$ let $u = 5x-1$ then $du = 5\,dx$

we want to replace dx with $\frac{1}{5}du$

my notation (from the days of KNUTH) is the assignment " $\longleftarrow$ " - like C's " = ", as in

if $du = 5\,dx$, then $\frac{1}{5}du \leftarrow dx$

as in " let $\frac{1}{5}du$ represent the value dx "

or simply $\frac{du}{5} = dx$

so, $\int (5x-1)^4\,dx = \frac{1}{5}\int u^4\,du = \frac{1}{5}\,\frac{u^5}{5} + C$

$= \frac{1}{5}\,\frac{(5x-1)^5}{5} + C = \frac{(5x-1)^5}{25} + C$

"tricks of the trade": look at $\int \frac{1}{2x+3}\,dx$ as $\int \frac{1}{x}\,dx = \ln|x| + C$

let $u = 2x+3$ then $du = 2\,dx$ and $dx = \frac{du}{2}$

$\frac{1}{2}\int \frac{1}{u}\,du = \frac{1}{2}\ln|u| + C$

$\int \frac{1}{2x+3}\,dx = \frac{1}{2}\ln|2x+3| + C$

$\int \sin 3x\,dx$ let $u = 3x$ then $du = 3\,dx$

$dx = \frac{du}{3}$

$\frac{1}{3}\int \sin u\,du = -\frac{1}{3}\cos u + C$

$= -\frac{1}{3}\cos(3x) + C$

Some glimpses at Guass' Law ... just minimal sketches ...
for details, see Brainwaves_8 and, especially, Brainwaves_9.

1 g of Hydrogen atoms separated
$\oplus$ q_1 = protrons at North Pole
r } $2R$
$\ominus$ q_2 = electrons at South Pole

Avogadro's Number
$N_A \approx 6.02 \times 10^{23}$ (mol)

charge of electron or protron $|e|$
where $|e| = 1.6 \times 10^{-19}$ c

information : R = radius of earth $\rightarrow 6.37 \times 10^6$ m

$k_e \rightarrow$ Couloumb's constant
$k_e = 8.99 \times 10^9 \frac{Nm^2}{C^2}$

$$F_e = k_e \frac{|q_1||q_2|}{r^2}$$

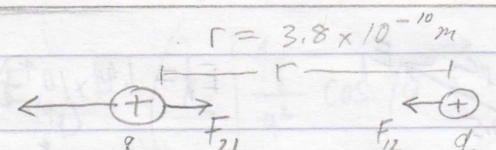
$q_1 \leftarrow +e$
$q_2 \leftarrow -e$
$r \leftarrow 2(6.37 \times 10^6 m) = 2R$

here,
$$q_1 = q_2 = N_A e = (6.02 \times 10^{23})(1.6 \times 10^{-19} c) = 9.65 \times 10^4 c$$

$$F_e = k_e \frac{(N_A e)^2}{(2R)^2} = 8.99 \times 10^9 \frac{Nm^2}{C^2} \frac{(9.65 \times 10^4 c^2)^2}{(2(6.37 \times 10^6 m))^2} = 5.15E5\ N$$

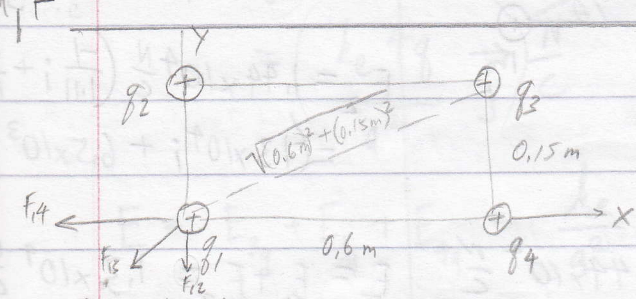
TI-85 : $\underbrace{Cc}_{k_e}((\underbrace{Na * ec}_{q_1 q_2})^2/((\underbrace{2(6.37E6)}_{r})^2) \Rightarrow F_e$

RADIUS OF EARTH



$$F_{21} = F_{12} = k_e \frac{q_1 q_2}{r^2} = k_e \frac{e^2}{r^2}$$
$$= 1.59 \times 10^{-9} N$$

TI
EM F



magnitude of force on q_1 :

$$|F_{12}| = k_e \frac{q^2}{(0.15m)^2} = 40\ N$$
$$|F_{14}| = k_e \frac{q^2}{(0.6m)^2} = 2.5\ N$$
$$|F_{13}| = k_e \frac{q^2}{(0.6^2 + 0.15^2)m} = 2.4\ N$$

$q \leftarrow q_1 = q_2 = q_3 = q_4$

$\vec{F}_{12} = 40N(\cos 270 \vec{i} + \sin 270 \vec{j}) = -40N\vec{j}$

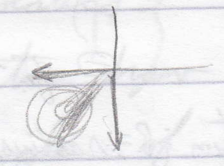
$\vec{F}_{14} = 2.5N(\cos 180 \vec{i} + \sin 180 \vec{j}) = -2.5N i$

$\vec{F}_{13} = 2.4(\cos(180+45) i + \sin(180+45) j)$
$= (-1.7 i - 1.7 j) N$

$$\Sigma \vec{F} = \vec{F}_{12} + \vec{F}_{13} + \vec{F}_{14} = (-4.2\vec{i} - 41.7\vec{j})\,N$$

$$|\vec{F}| = \sqrt{(-4.2\,N)^2 + (-41.7\,N)^2} = 41.9\,N$$

$$\theta = \tan^{-1}\left(\frac{-41.7}{-4.2}\right) = 84^\circ$$



85° in Quadrant III because $x < 0$ and $y < 0$

implies $180 + 85 = 265^\circ$

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q_1 (+) 40c

2000m

q_2 (−) 40c

$$\Sigma F = F_{12} + F_{21}$$

$$F_{12} = k_e \frac{q_1 q_2}{r^2} = k_e \frac{(40c)^2}{(2000m)^2} = 3.6 \times 10^6\,N$$ up from bottom

$$F_{21} = k_e \frac{q_2 q_1}{r^2} = 3.6 \times 10^6\,N$$ down from top

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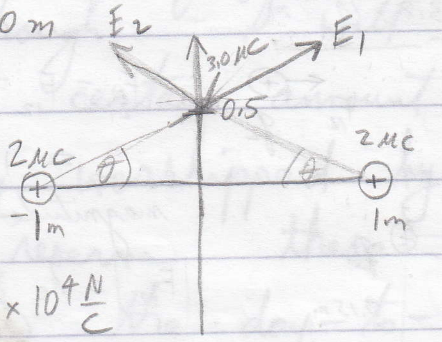
note: to balance weight of : $mg + qE = 0 \rightarrow E = \frac{-mg}{q}$

Calculate the electric force on a $-3.0\text{-}\mu c$ charge placed on the y-axis at $y = 0.50\,m$



$$E_1 = k_e \frac{|q_1|}{r_1^2} = k_e \frac{2 \times 10^{-6}\,c}{(1 + 0.25)\,m^2} = 1.44 \times 10^4 \frac{N}{c}$$

$$E_2 = k_e \frac{|q_2|}{r^2} = k_e \frac{2 \times 10^{-6}\,c}{1.25\,m^2} = 1.44 \times 10^4 \frac{N}{c}$$

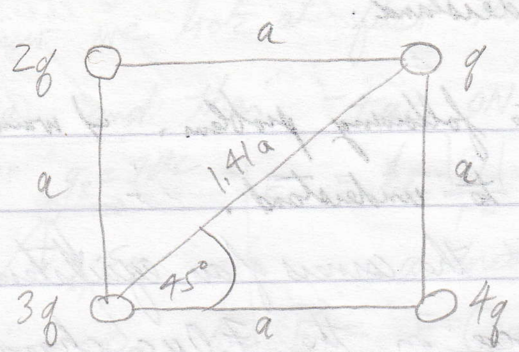
$$E_1 = 1.44 \times 10^4 \frac{N}{c}\left(\frac{1}{1.11} i + \right.$$
$$= (1.3 \times 10^4 i + 6.5 \times 10^3$$

$$E_2 = 1.44 \times 10^4 \frac{N}{c}\left(\frac{-1}{1.11} i - \right.$$
$$= (-1.3 \times 10^4 i + 6.5 \times 10^3$$

$$E = E_1 + E_2 = 1.3 \times 10^4 \frac{}{c}$$

$$F = qE = (-3.0 \times 10^{-6}\,c)(1.3 \times 10^4 \frac{N}{c}) = -3.9 \times 10^{-2}\,N$$

Determine the magnitude and direction of the electric field at the location of charge q.



$\sqrt{a^2+a^2} = \sqrt{2a^2}$
$= 1.41a$

11

$$\boxed{E = k_e \frac{q}{r^2} \vec{r}}$$

$$E_{(2q)} = \left(k_e \frac{2q}{a^2} \vec{i}\right) \frac{N}{C}$$

$$E_{(3q)} = \left(k_e \frac{3q}{(1.41a)^2} \cos 45° + k_e \frac{3q}{(1.41a)^2} \sin 45°\right) \frac{N}{C}$$

$$= k_e \left(\frac{1.07q}{a^2} \vec{i} + \frac{1.07}{a^2} \vec{j}\right) \frac{N}{C}$$

$$E_{(4q)} = \left(k_e \frac{4q}{a^2} \cos 90° \vec{i} + k_e \frac{4q}{a^2} \sin 90° \vec{j}\right) \frac{N}{C}$$

$$= \left(\frac{k_e 4q}{a^2} \vec{j}\right) \frac{N}{C}$$

$$E = E_{2q} + E_{3q} + E_{4q} = \frac{k_e}{a^2}\left(3.07q \vec{i} + 5.07q \vec{j}\right) \frac{N}{C}$$

The resultant force is $|F| = \sqrt{(3.07q)^2 + (5.07q)^2} = 5.93q$

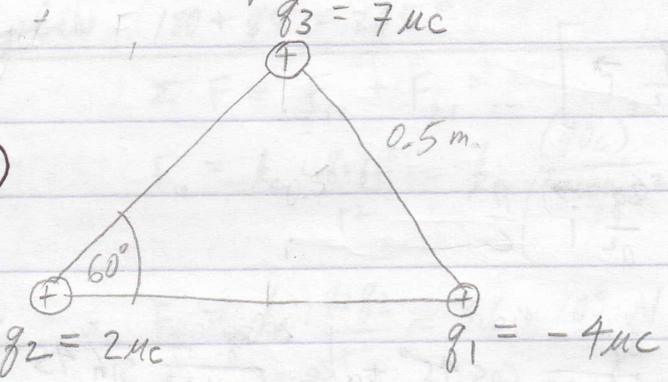
$\theta = \tan^{-1}\left(\frac{5.07}{3.07}\right) = 58.8°$

Main tennent for physics, for life in general.

"Do not memorize; understand."

There are two ways to do the following problem. I want to know why this is so. I want to understand.

Three point charges are located at the corners of an equilateral triangle. Calculate the net electric force on the 7.0μC charge.



$F = qE$

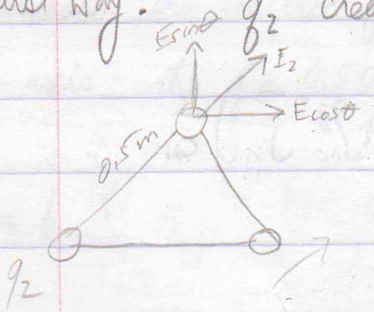
$F = q(E_1 + E_2)$

$F = \dfrac{k q_1 q_2}{r^2}$

$E = k\dfrac{q}{r^2}$

2 ways: get E_1, E_2; F OR get F_{31}, F_{32}, ΣF

first way: q_2 creates a field $E = k_e \dfrac{|q_2|}{r^2}$ at 60° above x direction

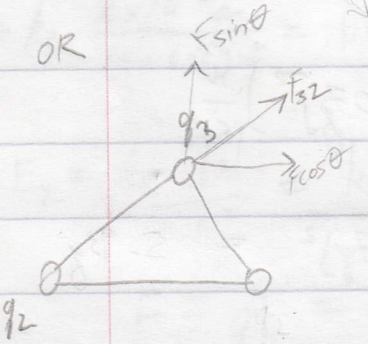


$\vec{E}_2 = E(\cos 60°\,\vec{i} + \sin 60°\,\vec{j})$

$E = 8.99\times10^{9}\,\dfrac{Nm^2}{C^2}\,\dfrac{(2\times10^{-6}C)}{(0.5m)^2} = 7.19\times10^{4}\,\dfrac{N}{C}$

$\vec{E}_2 = (3.6\times10^{4}\,\vec{i} + 6.23\times10^{4}\,\vec{j})\,\dfrac{N}{C}$

OR



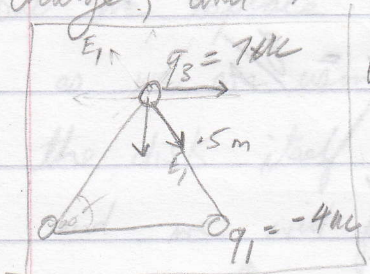
$F_{32} = k_e \dfrac{|q_3||q_2|}{r^2} \rightarrow = 8.99\times10^{9}\,\dfrac{Nm^2}{C^2}\,\dfrac{(7\times10^{-6}C)(2\times10^{-6}C)}{(0.5m)^2}$

$= 5.0\times10^{-10}\,N$

$\vec{F}_{32} = F_{32}(\cos 60°\,\vec{i} + \sin 60°\,\vec{j})\,N$

$\vec{F}_{32} = (2.5\times10^{-10}\,\vec{i} + 2.17\times10^{-10}\,\vec{j})\,N$

Note: I am doing both ways along the way to see how we come to the net electric force on charge $7\mu c$. So, now we look at first the field created by the $-4\mu c$ charge, and then $-4\mu c$ ON $7\mu c$ force.



$E_1 = k_e \frac{|q_1|}{r^2}$ at $180° - 60° = 120°$ above x direction

x direction is $\leftarrow$ "(−)"

$\vec{E}_1 = E(\cos 300° \vec{i} + \sin 300° \vec{j})$

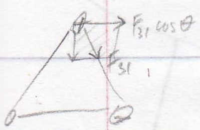
$E = 8.99 \times 10^9 \frac{Nm^2}{c^2} \frac{(4 \times 10^{-6} c)}{(0.5m)^2} = 1.4 \times 10^5 \frac{N}{C}$

$\vec{E}_1 = (+7.2 \times 10^4 \vec{i} - 1.2 \times 10^5 \vec{j}) \frac{N}{C}$

So now we have $\vec{E} = \vec{E}_1 + \vec{E}_2$,

but first let's look at the other way (F) for this charge

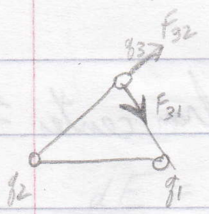
$F_{31} = k_e \frac{|q_3||q_1|}{r^2} = 8.99 \times 10^9 \frac{Nm^2}{C^2} \frac{(7 \times 10^{-6} c)(4 \times 10^{-6})}{(0.5m)^2}$



$F_{31} = 1.00 \, N$ $\quad \vec{F}_{31} = F_{31}(\cos 300° \vec{i} + \sin 300° \vec{j})$

$\vec{F}_{31} = (0.5 \vec{i} - 0.866 \vec{j}) N$ $\quad F = qE!$

$10^9 \cdot 10^{-12} \rightarrow 10^{-3}$



These are point charges, i.e. $E = k_e \frac{|q|}{r^2}$!

$\vec{E} = \vec{E}_1 + \vec{E}_2 = ((7.2 \times 10^4 + 3.6 \times 10^4)\vec{i} + (-1.25 \times 10^5 + 6.23 \times 10^4)\vec{j})$

$= (1.08 \times 10^5 \vec{i} - 6.27 \times 10^4 \vec{j}) \frac{N}{C}$

$F_{on\ 7\mu c} = qE = (7.0 \times 10^{-6} c)(\vec{E})$

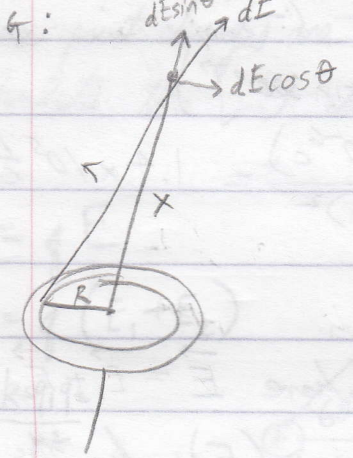
$= (7.56 \times 10^{-1} \vec{i} - 4.39 \times 10^{-1} \vec{j}) N$

$F = \sqrt{(.756)^2 + (.439)^2} = 0.874$ $\quad \theta = \tan^{-1}\left(\frac{.439}{.756}\right) = 30° \rightarrow 330°$

The infamous problem #37 from ch23:
uniformly charged ring and disk $q = 25\,\mu C$
radius $= 3\,cm = 0.03\,m$
determine Electric field at point 4 cm from center of object.

notes: $dq = \sigma\, dA$, $q = \sigma A$, $\sigma = q/A$

RING:



$$dE = k_e \frac{dq}{r^2}$$

$$dE_x = dE \cos\theta$$

$$\cos\theta = \frac{x}{r}$$

$$r = \sqrt{x^2+R^2}$$

$$dE_x = \left(k_e \frac{dq}{r^2}\right)\left(\frac{x}{r}\right) = \frac{k_e x}{r^3}\, dq$$

$$E_x = \int dE_x = \frac{k_e x}{r^3}\int dq = \boxed{\frac{k_e x q}{(x^2+R^2)^{3/2}}}$$

know we plug in variable values to get E_{ring} 0.04 m from center:

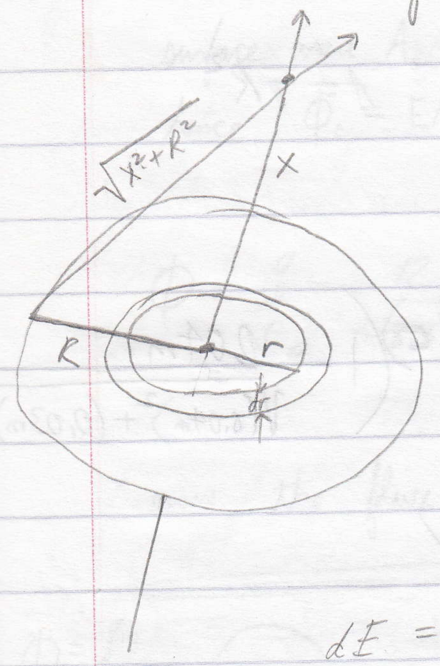
$$E_{ring} = 8.99\times10^{9}\,\frac{Nm^2}{c^2}\,\frac{(0.04m)(25\times10^{-6}c)}{\left((0.04m)^2+(0.03)^2\right)^{3/2}} = \boxed{7.19\times10^{7}\ \frac{N}{C}}$$

disk: For the disk, we must consider this disk as a set of concentric rings.

we use the E_{ring} equation $\frac{k_e x q}{(x^2+R^2)^{3/2}}$ from p14,

but we replace R with r,

as we are using variable R to represent the radius of the disk itself. r will be the radius of the ring, and we will find the definite integral from $r=0$ to $r=R$.



notes: $dA_{ring} = (2\pi r)(dr)$

Area of disk $= \pi R^2$

$R = 0.03m$

$x = 0.04m$

$q = 25\,\mu C$

$\sigma = q/A = q/\pi R^2$

$$dE = \frac{k_e x}{(x^2+r^2)^{3/2}} dq \text{, where } dq =$$

(area of ring) * (charge per unit area)

$dq = \sigma\, dA = \sigma(2\pi r\, dr)$

$$dE = \frac{k_e x}{(x^2+r^2)^{\frac{3}{2}}}(2\pi r \sigma\, dr)$$

$$E = \int dE = 2\pi\sigma k_e x \int_{r=0}^{R} r(x^2+r^2)^{-3/2}\, dr$$

let $u = (x^2+r^2)$

then $du = 2r\, dr$

$r\, dr = \frac{du}{2}$

$$E = 2\pi\sigma k_e x \int_{r=0}^{R} u^{-3/2}\, du/2 = 2\pi\sigma k_e x \left[\frac{u^{-1/2}}{-\frac{1}{2}} \cdot \frac{1}{2}\right]_0^R$$

$$E = 2\pi\sigma k_e x \left[-\frac{1}{\sqrt{u}}\right]_0^R = 2\pi\sigma k_e x \left(-\frac{1}{\sqrt{x^2+R^2}} + \frac{1}{x}\right)$$

15

Now, $E = 2\pi\sigma k_e x\left(\frac{1}{x} - \frac{1}{\sqrt{x^2+R^2}}\right)$

$$E = 2\pi\sigma k_e\left(1 - \frac{x}{\sqrt{x^2+R^2}}\right)$$

a closer look: $\sigma = \frac{q}{A} = \frac{q}{\pi R^2}$

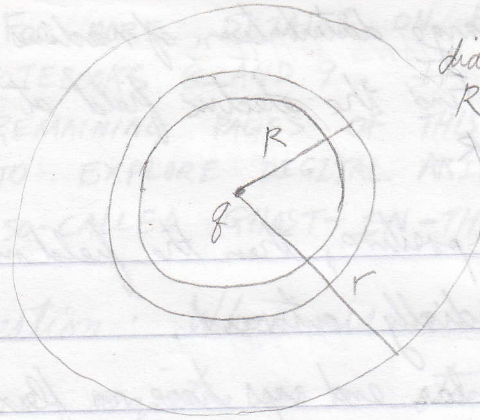
$$\boxed{E = \frac{2k_e q}{R^2}\left(1 - \frac{x}{\sqrt{x^2+R^2}}\right)}$$

$A = \pi R^2$

plug in: $E = \frac{2\pi\left(8.99\times10^9\,Nm^2\right)\left(25\times10^{-6}\,C\right)}{\pi\,(0.03m)^2\,C^2}\left(1 - \frac{0.04m}{\sqrt{(0.04m)^2+(0.03m)^2}}\right)$

check units: $\frac{Nm^2 \; C \; m}{m^2 \, C^2 \; m} \rightarrow \frac{N}{C}$ ✓

procede with calculation: $\boxed{E = 1.00\times10^8\,\frac{N}{C}}$



diameter = 22 cm = 0,22 m

R = 0.11 m

guassian surface → sphere

r > R

for $r < R$, $E = 0$

but for $r > R$, $E = \frac{k_e q}{r^2}$

surface area A_s of guassian sphere : $4\pi r^2$

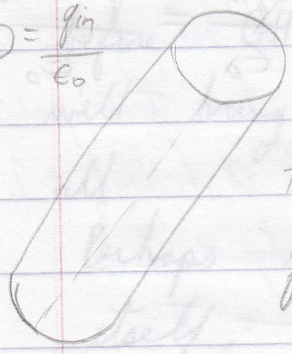
hence $\Phi_c = EA = \left(\frac{k_e q}{r^2}\right)\left(4\pi r^2\right) = \frac{1}{4\pi\epsilon_0} \frac{q}{r^2} \frac{4\pi r^2}{1} = \frac{q}{\epsilon_0}$

k_e

$\Phi = \frac{q}{\epsilon_0} = \frac{12 \times 10^{-6}\,C}{8.85 \times 10^{-12} \frac{C^2}{Nm^2}} = 1,36 \times 10^{6}\ Nm^2/C$

now the flux for half the shell would be $\Phi/2$

$\Phi = \frac{q_{in}}{\epsilon_0}$



$\Phi_c = 8.6 \times 10^4\ Nm^2/C$

the net charge inside the cylinder is $q_{in} = \Phi\epsilon_0$

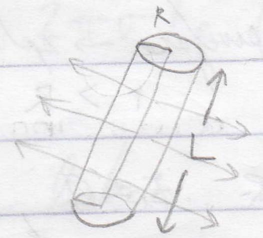
$q_{in} = \left(8.6 \times 10^4 \frac{Nm^2}{C}\right)\left(8.85 \times 10^{-12} \frac{C^2}{Nm^2}\right)$

$= 7.61 \times 10^{-7}\,C$

$= 0.761\ \mu C$

$= 761\ nC$ where $n \to 10^{-9}$

F1 Consider a long cyndrical charge distribution of radius R with a uniform charge density ρ. Find the electric field at distance r from the axis where $r < R$.



if ρ is positive, then the field must be radially outward.

* the circular end caps have no flux through them

$$\oint \vec{E} \cdot d\vec{A} = \frac{q}{\epsilon_0} \longrightarrow E \int dA = EA$$

surface area $A = 2\pi RL$ *(not the end caps $2\pi r^2$)

$$\rho = \frac{q}{V}, \quad q = \rho V, \quad V = \pi R^2 L$$

$$q = \rho V = \rho \pi R L$$

$$\Phi = EA = \frac{q_{in}}{\epsilon_0} \longrightarrow E(2\pi RL) = \frac{q_{in}}{\epsilon_0} = \frac{\rho \pi R^2 L}{\epsilon_0}$$

$$\boxed{E = \frac{\rho R}{2\epsilon_0}}$$

note: this is a good mental exercise.
It helps to drive home the relationship between charge density ρ, area, volume, etc

FOR MORE DETAILS ON PHYSICS II, SEE BRAINWAVES NOTEBOOKS 8 AND 9. I WOULD LIKE TO USE THE REMAINING PAGES OF THIS "INTRODUCTION TO LOGBOOK #59" TO EXPLORE DIGITAL ARITHMETIC – THE RAW NATURE OF THE SO-CALLED GHOST-IN-THE-MACHINE.

question: What is a register? a recording device

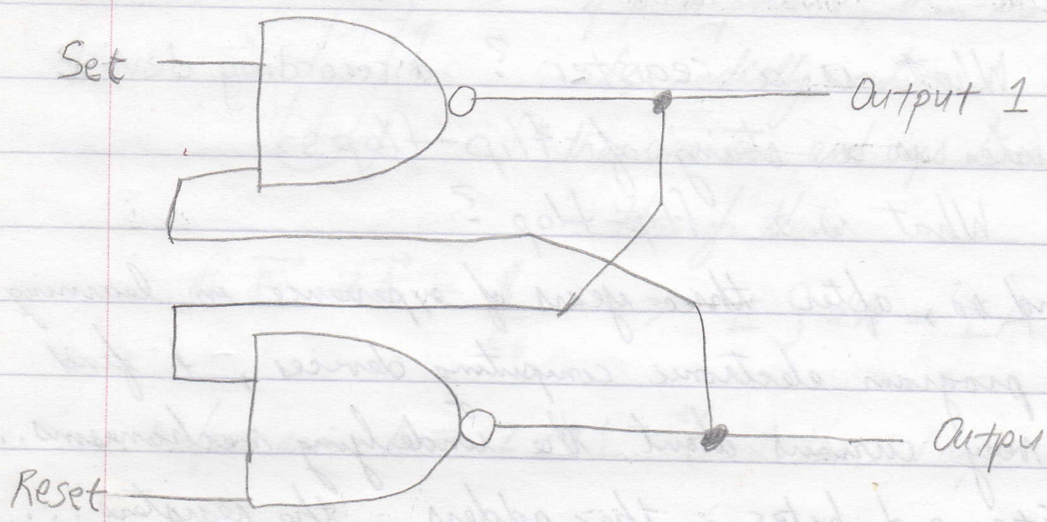
a register is a string of flip-flops.

question: What is a flip-flop?

... and so, after three years of experience in learning how to program electronic computing devices, I find myself very curious about the underlying mechanisms... the bits and bytes, the adders, the registers... Ink is called for. Why here, in the intro to L59 rather than the final pages of L58? This is the first of a new series. This is Scientia est Potentia (Knowledge is Power), the commonplace diary just before GHOST-IN-THE-MACHINE. The knowledge herein will bring understanding. It is not a ghost at all, but electronic devices known as flip flops. Perhaps the only Holy Spirit here is ELECTRICITY itself. I will give a definition of a flip-flop, I will draw diagrams (in pencil) of typical LOGIC-CIRCUITS.

Note that this is not what I am learning in school. I have been learning how to write code. My interests in the raw technology is highly personal.

FLIP-FLOP CONSTRUCTED FROM NAND GATES
(note: AND then NOT → NAND)



FLIP-FLOP an electronic circuit that can switch back and forth between two states (Ø and 1) and will remain in either state until changed.

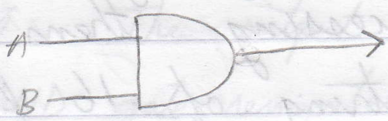
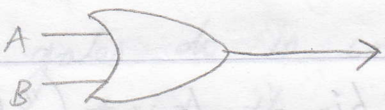
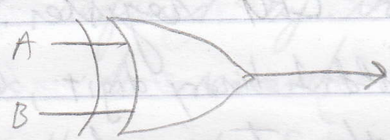
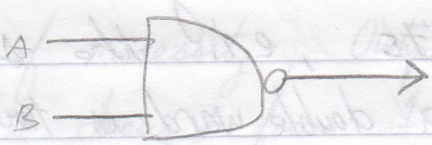
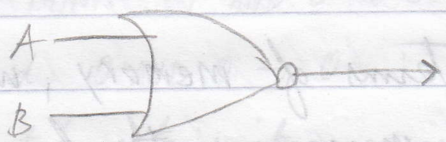
I believe Ø is low voltage and 1 is high voltage.

Flip-flops are the basic component of which CPU registers are composed. A flip-flop has two possi states: state 1 (Output 1 = 1) and state Ø (Output 1 = Ø
Output Ø is always the opposite of Output 1.

If Output 1 → A, then Output Ø → $\overline{A}$.

If both inputs (Set and Reset) are 1 when the flip-flop is powered up, it will settle into one stat or the other (known as GARBAGE). Bringing the "Set" input to Ø will put the flip-flop into state 1, and bringing the "Reset" input to Ø

will put the flip-flop into state 0. Whenever both inputs are 1, the flip flop stays in whatever state it was already in. Thus, a flip-flop is a 1-bit memory.

GATE FUNCTION	LOGIC SYMBOL	MATH	A	B	out
AND		"$A \cdot B$"	0	0	0
			0	1	0
			1	0	0
			1	1	1
OR		"$A + B$"	0	0	0
			0	1	1
			1	0	1
			1	1	1
XOR		$A \oplus B$	0	0	0
			0	1	1
			1	0	1
			1	1	0
NOT		$\overline{A}$	0		1
			1		0
NAND		$\overline{A \cdot B}$	0	0	1
			0	1	1
			1	0	1
			1	1	0
NOR		$\overline{A + B}$	0	0	1
			0	1	0
			1	0	0
			1	1	0
XNOR			0	0	1
			0	1	0
			1	0	0
			1	1	1

what is a register?

a register is a row of flip-flops used to store a group of binary digits while the computer is processing them. A register consisting of a string of 16 flip-flops can store "words" that are 16 bits long.

word - a group of binary digits ("b-its") equal in size to one CPU register. The number of bits (1 bit can hold 1 binary digit, 0 or 1) in a word depends on the type of computer being used. A word on 386-based machines is 32 bits. On the original IBM PC's, a word was 16-bits, e.i. the size of one CPU register. a double word is twice the size of a word

When speaking in terms of memory, we say a flip-flop is a 1 bit memory; therefore a register made up of 16 flip flops is a 16 bit memory.

What is the nature of this memory? It is a reflection... The flip-flop is the basic unit of memory. In saying that flip-flops have memory, engineers are indicating something essential about AND, OR, and NAND gates — namely, that

these units lack memory. If both inputs to a two input AND gate are 1's, the AND gates output will also be a 1. (p 21) If one of the inputs is changed to a Ø, then the two inputs become a 1 and a Ø. The output is therefore a Ø. Does the AND gate remember that it was previously in the state when both its inputs were 1? It does not. All these gates do is combine whatever inputs happen to be present at the particular moment, and produce the output required by the appropriate truth table.

Flip-flops do remember what the previous state was. Suppose the inputs Set and Reset of the cross-coupled NAND gates that constitute the flip-flop on p 20 are Set = 1 and Reset = Ø and Output 1 ~~is~~ 1, and ∴ of necessity, Output Ø = $\overline{\text{Output 1}}$ = Ø

If Set is changed from 1 to Ø, will Output 1 change? THINK 1 AND 0 → 0 ∴ 1 NAND 0 → 1

and 0 AND 0 → 0 ∴ Ø NAND Ø → 1

No. Output 1 retains its previous state, and in this sense, does indeed remember — or, at the very least, reflect — what happened before.

The sequence of input states matters. A circuit that uses logic gates such as AND, OR, and NOT is called a combinational circuit, whereas those circuits that employ devices such as flip-flops are sequential circuits.

25 As far as engineers are concerned, and here I confess to being a programmer (who has the right to wonder about engineering problems as well), each

flip-flop serves as a temporary storage slot for one binary digit - that is, a Ø or a 1 (but which I suspect is low or high voltage). A flip-flop is itself a one bit register. Now we are getting somewhere.

Earlier I defined a flip-flop as a 1 bit memory. Now as a 1 bit register. Register implies recording device — and Recording is the nature of the concept of memory.

One bit registers aren't enough though. We require strings of flip-flops. A very large part of the operations of computers consists of the transfer of words from one register to another. It is by becoming fully comfortable with the mechanics of register-to-register transfers that both the hardware and the software aspects of a computer emerge as truly meaningful.

Notice how the electronic pulses generating the states in the flip flops are the binary Numbers from Ø to 7.

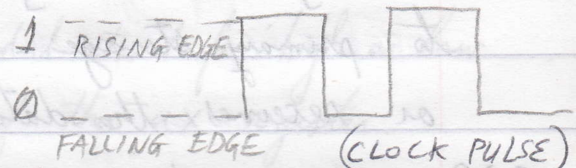
clocks and counting

Clock impulse comes from a quartz crystal.

The crystal can be made to vibrate millions of times per second by applying a voltage accross it. This phenomenon is called the piezoelectric effect ("pee-ay-zo")

A piezoelectric quartz crystal provides a highly stable frequency source, one that is little affected, by normal temperature changes. [this is just a side note]

Here is a comparison of the arithmetic vs electronic approach where a pulse is



0-to-1 transition → The rising edge

1-to-0 transition ⟶ The falling edge

	C	B	A
BEFORE 1st clock pulse arrives	0	0	0
AFTER 1st clock pulse	0	0	1
AFTER 2nd clock pulse	0	1	0
AFTER 3rd clock pulse	0	1	1
AFTER 4th clock pulse	1	0	0
AFTER 5th clock pulse	1	0	1
AFTER 6th clock pulse	1	1	0
AFTER 7th clock pulse	1	1	1

When flip flop A makes the transition from 1-to-0, flip-flip B changes states, and when flip-flop B makes the transition from 1-to-0, flip-flop C changes state.

From my notes from OST class — examples of registers
(BRAINWAVES_7)

ACC accumulator - 16-bit one of the ~~operators~~ operands must be in the accumulator, the other in primary storage

PSIAR primary storage instruction address register 8-bit points to the location in primary storage of the next machine language instruction to be executed.

SAR storage address register 8-bit involved in all references to primary storage. It holds the data being WRITTEN to or receives the data being READ from.

SDR storage data register 16-bit (like the SAR) is involved in all references to primary storage. It holds the data being WRITTEN to or received the data being READ from primary storage AT THE LOCATION ~~of~~ SPECIFIED IN THE SAR.

TMPR temporary register - 16-bit used to extract the address portion (rightmost 8 bits) of the machine instruction in the SDR so that it may be placed in the SAR.

CSIAR control storage instruction address register this register points to the location of the next microinstruction (in control storage) to be executed.

MIR microinstruction register - contains the current microinstruction being executed.

general purpose registers - used by programmer

program counter (instruction pointer)

- contains the main memory address of the next instruction to be executed by the computer.

stack pointer - when we push a word of data onto a stack, it is stored in a particular memory location.

Note that the registers, unlike addresses in main memory, are not numbered. They are given symbolic identifiers, such as in the 8088 microprocessor:

general registers

ax	ah	al
bx	bh	bl
cx	ch	cl
dx	dh	dl

where ah and al stand for high or low 8 bytes of the ax register

Memory

0
1
2
:
9FFFF

640K

read only
display
cards, etc

pointer index

sp stack
bp base
si source
di destination

segment registers

cs code
ds data
ss stack
es extra

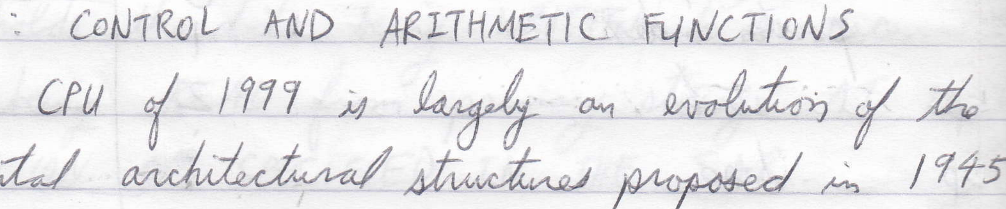
flag
ip instruction pointer

Main memory is distinguished from the registers through the presence of numeric addresses that are used to store and fetch information.

BUFFERS – the term buffer denotes a portion of the computer's memory that is being used as a temporary storage location. Buffer storage is often used for data which is being sent to or received from an external input or output device. Many computers have circuitry which allows external devices to fetch or store information. This is accomplished by using the computers main memory and what is called DMA (direct memory access). By placing a portion of the output data into a buffer, the main program can call upon the services of the OPERATING SYSTEM to affect an input or output transfer in a more efficent way than would otherwise be possible. Any memory that is used as temporary storage can be called a buffer.

THE CPU: CONTROL AND ARITHMETIC FUNCTIONS

The CPU of 1999 is largely an evolution of the fundamental architectural structures proposed in 1945 by von Neumann. At the HEART of most processors is an ARITHMETIC AND LOGIC UNIT. This unit takes input from two registers and provides output to a third. Until recently there was only a single full-width ALU even on large mainframe computers. An ADDER for two 32-bit or larger binary numbers is a fairly complex circuit.

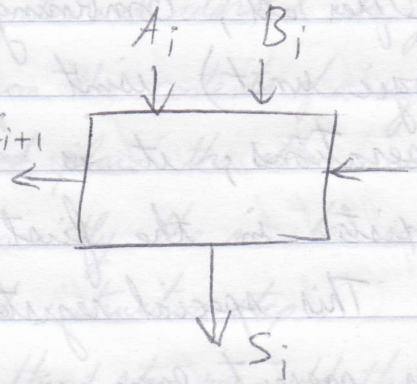


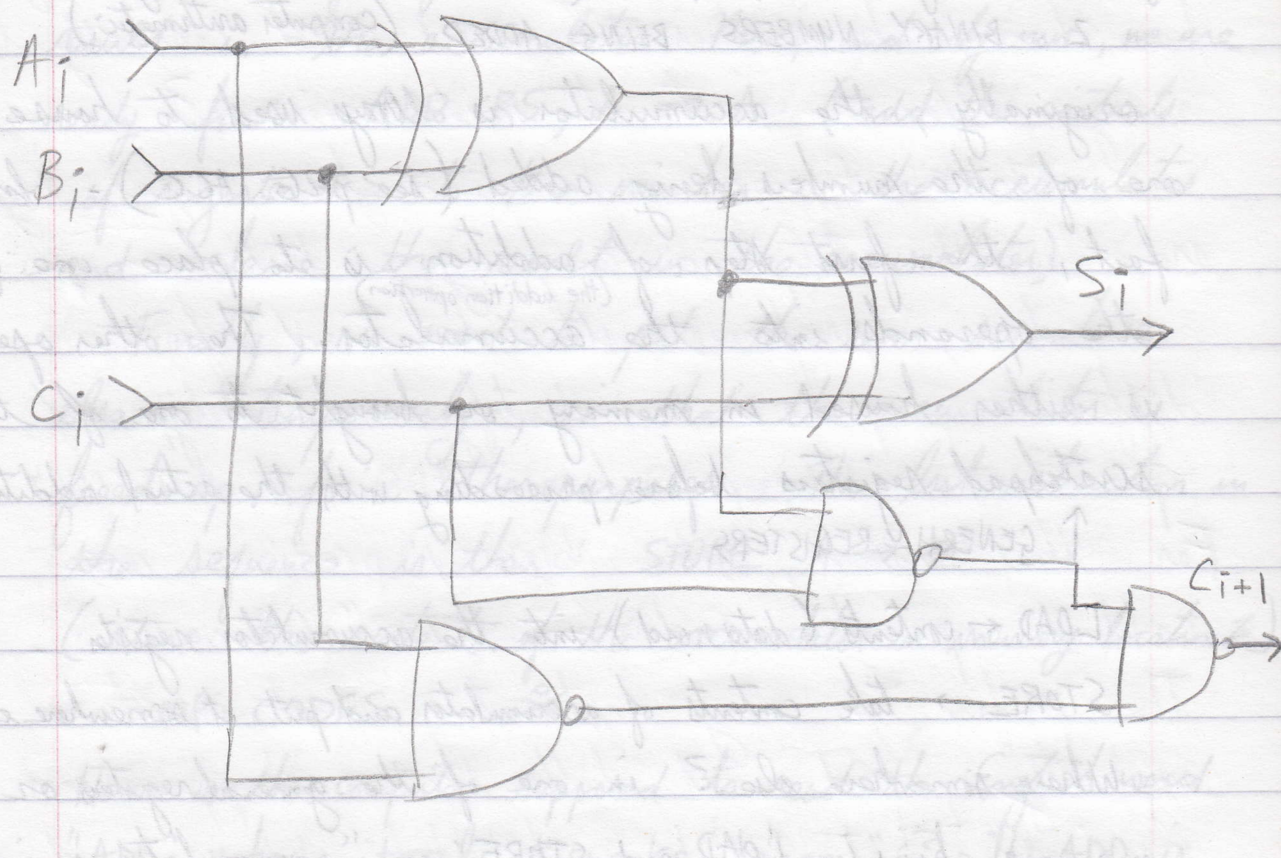
A one-bit Full Adder adds two binary digits A_i, B_i, and one carry-input C_i to produce a sum output S_i and a carry-output C_{i+1}

$$S_i = A_i \oplus B_i \oplus C_i$$

$$C_{i+1} = A_i B_i + B_i C_i + C_i A_i$$

$$\begin{array}{r} C_i \\ A_i \\ + \quad B_i \\ \hline C_{i+1}\ S_i \end{array}$$





NOTE: PAUSE HERE 1999275 2045

Note: ~~co~~ microprocessors are often referred to as central processing units (CPUs). Every microprocessor has at least one general purpose register that is special. It is singled out as the one which results are held. After all, combining data in the ALU (arithmetic and logic unit) isn't just another facet of a computer's operations; it is the main reason the computer exists in the first place!

This special register is called the accumulator, and it is present even in microprocessors that don't have any other general-purpose (or SCRATCHPAD) registers.

2 BINARY NUMBERS BEING ADDED (computer arithmetic)

originally, the accumulator is allways used to house one of the numbers being added (see p26 ACC). In fact, the first step of addition (the addition operation) is to place one of the operands into the accumulator. The other operand is either housed in memory or brought to one of the scratchpad registers before proceeding with the actual addition.

↑ GENERAL- REGISTERS

LOAD ← contents (data word) into the accumulator register

STORE → take contents of accumulator and put it somewhere else

Where somewhere else? in one of the general registers or memory chips. LOAD and STORE are "accumulator-specific transfers".

Other register-to-register transfers are needed, but they are handled by a third kind of instruction: MOVE.

assume 1011 0101 is sitting in memory location X, where X stands for a 10 bit address. Our first instruction:
LOAD X → A (load contents of register with address X into register A.)
Here there is a switch in focus from the contents of a register to its address. Now we want to ~~load~~ place the other number, 1101 0011, into register #5. Currently the number is in memory location Y. The second instruction step:
MOVE Y → R5 In the third step we add the two numbers by feeding both into the ALU. We park the result in the accumulator. Now, and only now, we are ready for: ADD R5, A → A (add the contents of register #5 to the number in the accumulator and leave the result in the accumulator).

Finally, we want to put the sum somewhere else temporarily, so that the accumulator is freed up for other purposes. The last instruction in the sequence is then: STORE A → Z
(store the contents of the accumulator in memory location Z)

OP CODES

How is the computer supposed to read the English word "ADD" when it only "speaks binary"? If ADD is in binary, how does the microprocessor know that the

sequence of 0s and 1s that make up the letters A-D-D mean that the machine should obtain the sum of the two binary numbers that follow the word?

While instructions such as LOAD, STORE, and MOVE must be translated into binary digits to be understood all they involve is simple register-to-register transfers. Instructions such as ADD and SUBTRACT are more complicated.

In order to be housed in the computer's memory every instruction must be translated into a string of 0s and 1s. Assuming that this has already been done, how does the CPU read correctly the many different instructions it receives?

Think of area-codes and how useful they are to the telephone company. With our computers, prefixes will be used for a different purpose: to identify various types of operations on data, such as ADD and MULTIPLY. For that reason, the binary prefixes are called operation codes — or "OP codes". The prefix in every instruction word is there explicitly, and it tells the microprocessor precisely what to do with the addresses of the data words trailing along right behind it!

if there are 16 general purpose registers, we need 4 bits to address them all, since $2^4 = 16$.
Hardware has a direct impact on software — the way the instructions are written.

typical format of input/output instruction:

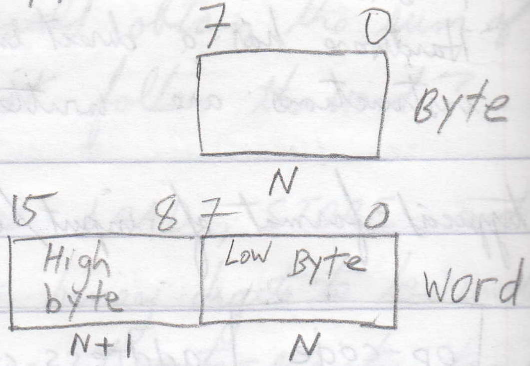
op code	address code	command code

The op code tells the CPU immediately that it is dealing with an input/output instruction. It must tell the CPU which one (input or output?).
The address code singles out one register in the interface, and hence allows the conversation in which the CPU subsequently takes part to be in point-to-point instead of broadcast mode.
The command code must contain bits that (through the interface) tells the peripheral such things as (1) input some information to the CPU (2) receive some output from the CPU.
In short, the CPU, through the command code, takes charge of readying the peripheral either to input or output information, and then makes sure it does it.

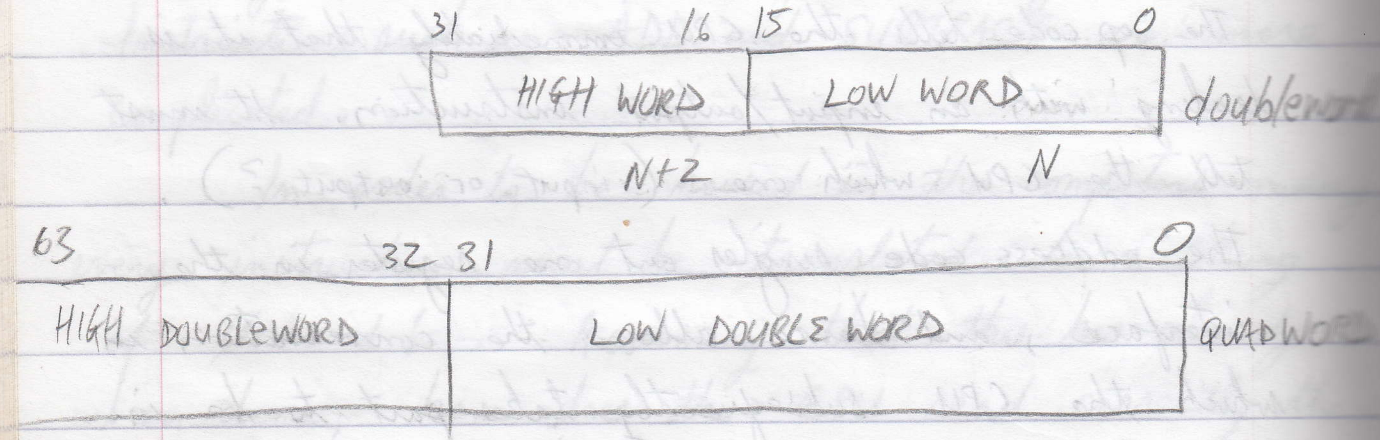
ADD EAX, 14

Fundamental Data Types

Intel 80x86



mainframe 16 bits → halfword
32 bits → word
64 bits → doubleword



32 BIT GENERAL PURPOSE REGISTERS
(EAX, EBX, ECX, EDX, ESI, EDI, ESP, EBP)

16 BIT GENERAL PURPOSE REGISTERS
(AX, BX, CX, DX, SI, DI, SP, BP)

8 BIT GENERAL PURPOSE REGISTERS
(AH, BH, CH, DH, AL, BL, CL, DL)

SEGMENT REGISTERS
(CS, DS, SS, ES, FS, GS)

EFLAGS REGISTERS

SYSTEM REGISTERS
GDTR: global descriptor table
IDTR: interrupt descriptor table

Some instructions, such as DIV and MUL, use quadword operands contained in a pair of 32 bit registers. Register pairs are represented with a colon separating them.

in EDX:EAX, EDX contains the high order bits and EAX contains the low order bits.

15 0	31 0
SEGMENT SELECTOR	OFFSET

(DISPLACEMENT → STATIC)

DISPLACEMENT - an 8-, 16-, or 32-bit value

BASE The value in a general purpose register

INDEX The value in a general purpose register

SCALE FACTOR a value of 2, 4, or 8 that is multiplied by the index value.

The offset which results from adding these components is called an effective address.

$$\underset{\text{BASE}}{\begin{bmatrix} EAX \\ EBX \\ ECX \\ EDX \\ ESP \\ EBP \\ ESI \\ EDI \end{bmatrix}} + \underset{\text{INDEX}}{\begin{bmatrix} EAX \\ EBX \\ ECX \\ EDX \\ EBP \\ ESI \\ EDI \end{bmatrix}} * \underset{\text{SCALE}}{\begin{pmatrix} 1 \\ 2 \\ 3 \\ 4 \end{pmatrix}} + \underset{\text{DISPLACEMENT}}{\begin{bmatrix} \text{NONE} \\ 8\text{ bit} \\ 16\text{ bit} \\ 32\text{ bit} \end{bmatrix}}$$

OFFSET = BASE + (INDEX * SCALE) + DISPLACEMENT

exploring assembler

a: debug ; - a 100 (starting at OFFSET 100)

14F4:0100 → segment : offset

14F4:0100 mov ax, 1FF

(move the hex number 1FF into the ax register)

14F4:0103 add ax, 3D (add 3D to that register)

14F4:0106 nop (placeholder : a no-op does nothing)

14F4: 0107 <E><R>

- u 100 106 (unassemble the program that appears in locations 100 through 106)

```
14F4:0100  B8FF01   MOV AX, 01FF
14F4:0103  053D00   ADD AX, 003D
14F4:0106  90       NOP
```

- g = 100 106 (run = start stop)

```
AX=023C  BX=0000  CX=0000  DX=0000  SP=FFEE
DS=ES=SS=CS=14F4  IP=0106  NV UP EI PL NZ AC
14F4:0106  90   NOP
```

The answer is on ax: 23C hex

- q (q for quit)

1FF h → 511 d
3D h → 61 d
23C h → 572 d

refer to page 27. The problem just solved contained data in the positions shown:

General Registers	ax	0 2	3 C	
	bx	0 0	0 0	
	cx	0 0	0 0	
	dx	0 0	0 0	
Pointer / Index	sp	FF	EE	stack
	bp	0 0	0 0	base
	si	0 0	0 0	source
	di	0 0	0 0	destination
Segment Registers	cs	14	F4	code
	ds	14	F4	data
	ss	14	F4	stack
	es	14	F4	extra
	Flag	0010	00000	
	ip	01	06	instruction pointer

Memory

0100	B8
	FF
	01
	05
	3D
	00
0106	90

The code for the MOV instruction is B8 and the operand 1FF is stored in reverse order in the next two slots. This reverse order is characteristic of the Intel 80x86 family. Not only are the two bytes of the word reversed, but a complete four byte address is stored with its offset portion preceding its segment portion.

I think that is enough! There is a place for scientific oriented notes → Brainwaves. Write in Brainwaves_7! Save this for daily "poetics".

note about Physics II problems:

It is best to remember the more complex SI units of measurement in terms of the fundamental SI units: meters, seconds, kilograms, amperes

$\downarrow$ $\downarrow$ $\downarrow$ $\downarrow$

distance, time, mass, current

definition of ampere: if two long, parallel wires 1 m apart carry the same current and the force per unit length on each wire is 2×10^{-7} N/m, then the current is defined to be 1 A.

notice how the famous F = ma comes together:

$$F \text{ newtons} = (m \text{ kg})(a \tfrac{m}{s^2})$$

complex unit			fundamental units	relationships
c	charge	C coulombs	$A \cdot s$	
F	force	N newtons	$\frac{kg\, m}{s^2}$	
E	electric field	$\frac{N}{C}$	$\frac{kg \cdot m}{A \cdot s^3}$	$\frac{N}{C} = \frac{V}{m}$
K	work	J joules	$\frac{kg \cdot m^2}{s^2}$	$N \cdot m$
V	electric potential	V volts	$\frac{kg \cdot m^2}{A \cdot s^3}$	$\frac{N \cdot m}{C} = \frac{J}{C}$
C	capacitance	F farads	$\frac{C^2 s^2}{kg\, m^2}$	$\frac{Q}{V}$

"I don't care about my personality and I am not interested in cultivating it. I don't want to treat my life as an experiment, but to be what my life makes me. It is I who am the experiment, and it is life that forms and controls me. If I had enough strength and patience, I know how completely impersonal I would become, how far my strength would carry me on the path to active nothingness. What has always held me back is my personal vanity." Albert Camus

TRACKING MY ORGANISM'S MENTAL STATES

1999 292 TU 19 OCTOBER 23:50hrs Julian Date (day) 2451471.7

Even though it is 20 Oct in just ten minutes, it is a ritual to link the volumes together where an ending JD equals the start JD of the next volume.

I have much Physics studying to engage in. I love it. I am not complaining.

293 WE 20 OCT 03:45 hrs

I got out of bed easily. Special note: I notice that when I verbalize the word capacitor I get a "robotic" flash... I like what is happening. I like the effect knowledge is having on me. I think I am becoming more impersonal.

Before leaving, I will have a cigarette and mentally cogitate upon a circuit.

293 20:30 hrs I received a memo from Brookdale — my transcript is not being sent because of an outstanding financial obligation. I have been on the phone with BCC Accounts Receivable — I have contacted DVR — returned email to Kathleen Lambertson — she just happened to send me mail today to see if I have heard anything from Rutgers. I returned email to Shari — Chuck Sany's Shari. I want to prepare for physics exam,

but I am very anxious/upset about this hold up. I wonder what happens next. Will Kathleen Lambertson come to my rescue? She wants to see me become an Analyst... I will be focusing on numerical analysis at Rutgers.

It is difficult to focus on this physics exam with my transcript being held at BCC.

Life is problematic.

I am my problem. I am a problem to myself. I mean this in the most existential way.

I will try to review the main problems one more time, and then I want to get to sleep before 02:00 as I will want to rise early enough to be over at the testing center by 10AM. I will give myself 7 hours...

I may want to stop by Accounts Receivable to check in about the status of my "OUTSTANDING FINACIAL OBLIGATION".

If all goes well between Chris Nowick and Kathleen Lambertson, perhaps Records will release my transcript and my application will be processed by Rutgers before November 1st.

To the business entity, Brookdale Community college, I am an outstanding financial obligation owed. To them, I have to pay up. They don't give a fuck about my GPA or my "abilities". They make me sick. They really are selling credentials — knowledge is not what they sell. Knowledge is an accidental consequence of their money making venture. I would not even be where I am at now, on the verge of receiving an associates degree, if it were not for the funding of my tuition by the state of New Jersey, Division of Labor, Department of Vocational Rehabilitation. How humbled I ~~am~~ stand before the machines of industry. How very meek, powerless, insignificant — fortunate and privelaged to have been granted access into the Church of Reason.

I know having Xiaxuang Liu as a professor is a valuable life experience. It is all for sale, and I do not have money. I am denied access if it were not for NJDOLDVR and my so-called bipolar disorder, my manic depressive mental condition.

I appreciate every moment of my education.

47

1999 296 SA 23 OCTOBER

02:00 hrs I finished cr5 of Java projects. There are 12 for credit, 2 more for honors, and another 2 for high honors — total 16. I have 5 done. I will stay on top of it from now on.

My stomach aches. Thinking about my image in space and time here in Freehold. I just happened to run into Fred Dawes and Eric Antico. I trust Eric ... Fred, I wouldn't trust. Why I bothered trying to explain how I was pursuing a degree in Mathematics and Computer Science, I do not know. He will only resent it. He could never fathom my love for learning. He thinks I am strange. I am looking forward to being exposed to all those females — all those young females, but I am mostly enthusiastic about it being a Research University. I am not going there to drink booze. I am going there to train to become a professional scientist.

I can see that this education just may be enough to liberate my mind from the prison-image of me from some of the locals.

Yes, Fred, I want to earn my living with my brain.

Fred once pissed on my rug — in the Tark House. 51
I guess I never quite forgot that. Fred was Allison Gray's sweetheart back in 1979 before/during her little infatuation with me. Fred was always fast — faster than me? I think so, by a fraction. Now he is a huge good ole boy. What a joke I seem to be in their eyes — — people like Lonnie Gray ... fuck them ... I am getting out of this town.

Arthur Schopenhauer enlightened me. I can see that I would be despised by half a dozen blockheads, despised and ridiculed.

I stopped by the shop today. Man, I do not miss that place. Even though Claude has respect for me, he is an ignoramus. He has no clue as to what it is I have been up to these past two years. When he thinks of math, his imagination can ~~ak~~ only go so far... architect~~ure~~ - whatever. He means no harm. Still, I certainly am glad to be in an academic environment. Claude and Tom (Sandle) believe that kids come out of college not knowing a damn thing. We shall see about that. I think I will master a true craft: computer science.

296 03:00 As much as I complain about worrying what other people's opinions are of me, I really don't care. I am obviously very into my studies. I am a thinker. I want as little to do with other people as possible. I think of Professor Olaoye and how I charmed her with my wit. She really appreciated my verbal skills. These are the kinds of minds I want to be around. ~~Each~~

Each creature presents a dilemma to itself. Let people say or think what they will about me. I understand enough about life to know that the ~~sev~~ burden of existence weighs heavy upon each individuals nerves.

Now I am extremely tired. I am so engrossed in my studies that I do not have the oportunity to get depressed about being "a skinny runt". Nature compensates. Wow I am tired. I will read my last entry, then I will fall asleep reading Schopenhauer.

This philosopher looks forward to getting away from Freehold, starting anew, developing his intellect. With the Java code written for cr4 and cr5, I will devote my energies to Operating Systems Technology tomorrow.

This is my life. I am a scholar.

What books to return? What books to renew? Looking at Digital System Design (ISBN 0-13-214289-9), I notice that the structure of assembler language lends a few clues as to how I might go about constructing a translator.

ARITHMETIC and LOGIC instructions will specify a single operation upon one or two operands. What ~~will~~ is the general format of these processor instructions.

Machine instructions are notionally split into two parts, an operation field and an operand field: | OPERATION | OPERAND |

The operand field will specify the numbers that are to be used in the operation. It is usual to refer to the operand field as the ADDRESS FIELD.

operation field | first operand | second operand | result

General Instructions

Transfer (load/store and more)

contents of one location are copied to another location.

Arithmetic and logical (ADD, SUB, MUL, DIV; and, or, not, etc)

Jump/Branch (if conditions exist, do)

Control (stop, wait, etc)

I can return Digital System Design, IBM PC ASML, 16Bit MP

I will renew the 3 books on Neural Networks. In fact, I will begin my Neural Networks paper with a quote from Von Neumann (p51) + ch17, "Teaching Arithmetic to a Neural Network" looks promising.

299 10:00hrs I called Rutgers Admissions 445-3777, They are still processing applications, switching to a new computer system. They now tell me to try back at the end of next week (around November 4th)!

Holy, holy, holy shit. Presently I am ON PHYSICS ch 27 #43. I will try to complete the rest before driving over to LAB. We get the results back of our exams in Physics ch 26 to 23 ~~exam~~ I am hoping for a 90, but bracing myself for an 83.

299 16:30hours The average grade on the first Physics II exam for the class as a whole was 68! That was a tough test. The highest grade was a 90. When I saw the kid next to me (who was confident he did well) was a 52, I thought to myself, "I will be happy with an 80". I got my test back — I got the 90! That was the most difficult test I have ever taken. I hope the next one is easier.

As for ch 27 homework, not one other person ~~was~~ besides myself had done the homework. We will have a quiz on Thursday. So, tonight I will start ch 28 problems and work on the C version of my translator (I got the 3 books from Joe). Tomorrow night I will review ch 27... or...

161 I may review some formulas from ch 27 (Current and Resistance) herein before doing a few ch28 problems; then, tomorrow night I can review these before the test/QUIZ.

average current $\bar{I} = \frac{\Delta Q}{\Delta t}$ $\frac{\text{change in charge}}{\text{change in time}}$

$I \equiv \frac{dQ}{dt}$ AMPS → coulombs per second

AMPERAGE $I \propto v, q; A$

amperage is proportional to (dependent on) velocity; charge, area

new concept: charge density $n \leftarrow \frac{N}{V}$ $\frac{\text{number of carriers}}{\text{volume } (m^3)}$

$q \leftarrow$ charge carried by one carrier

$\Delta Q = Nq \leftarrow$ (number of carriers)*(charge per carrier)

if $n = N/V$, then $N = Vn$

if $V = A\Delta X$ then $\Delta Q = Nq = \overbrace{(nA\Delta X)}^{N}q$

and $I = \frac{\Delta Q}{\Delta t} = \frac{nA\Delta Xq}{\Delta t}$

note that velocity of carrier $v_d = \frac{\Delta X}{\Delta t}$

$I = nAqv_d \leftarrow$ charge density * area * charge * velocity

Physics II (and its mathematics) was my religion before I got the 90 on the exam. Now an even more religious feeling possesses me!

So far, $I \equiv \frac{dQ}{dt}$ units AMPS where $1A = \frac{1C}{s}$

"is defined as" $I = nqv_dA$

current density $J \equiv \frac{I}{A}$; $J = nqv_d$

Ohm's Law $\vec{J} = \sigma \vec{E}$

at this point, one reflects, "Isn't Ohm's Law $R \equiv \frac{V}{I}$?" Resistance = Voltage / Amperage. or $I = \frac{V}{R}$

COGITATION #001: This is not so mysterious if one pauses a moment to reflect on the fundamental units of measurement. resistance is measured in ohms Ω. the basic units $\frac{V}{I}$ break down as follows: Volts $\rightarrow \frac{\text{Joules}}{\text{coulombs}} \rightarrow \frac{J}{C} \equiv \frac{J}{A \cdot s}$

$\frac{J}{C} \rightarrow \frac{N \cdot m}{A \cdot s} \rightarrow \frac{kg\ m^2}{A\ s^3}$ Amperes $\rightarrow \frac{\text{Coulombs}}{\text{second}} \rightarrow \frac{C}{s}$

remember 1 Coulomb $\equiv A \cdot s$, well $1\,A \equiv \frac{C}{s}$

hence, $\boxed{1\,\Omega} \equiv \frac{V}{I} \rightarrow \frac{kg\ m^2}{A\ s^3} \cdot \frac{1}{A} \rightarrow \frac{kg\ m^2}{A^2\ s^3} \rightarrow \frac{\text{Volts}}{\text{Amps}}$

so, $\frac{kg\ m^2}{A^2 s^3}$ is not very intuitive — this is Ω's.

$I \rightarrow A$ $\cancel{A^2/s^2 \rightarrow C^2}$ Volts $\rightarrow \frac{J}{C} \rightarrow \frac{kg\ m^2}{A\ s^3}$ $\therefore \Omega \equiv \frac{kg\ m^2}{A\ s^3} \cdot \frac{1}{A}$

I think, besides memorizing the basic SI units, I will also reflect upon the DIMENSIONS.

53

VOLTAGE $\frac{\text{mass} * \text{length}^2}{\text{charge} * \text{time}^2}$, where charge itself is amps * seconds and length^2 is area.

voltage : $\frac{\text{mass} * \text{area}}{\text{charge} * \text{time}^2} \rightarrow \frac{Kg\ m^2}{A\ s^3}$ (charge → C → A·s)

current (amperage) : ~~charge~~ $\frac{\text{charge}}{\text{time}}$ $\frac{C}{s} \rightarrow \frac{A \cdot s}{s} \rightarrow A$

Hence, back to resistance:

resistance (ohms) : $\frac{\text{mass} * \text{area}}{\text{charge}^2 * \text{time}}$ $\frac{Kg\ m^2}{A^2 \cdot s^3} \rightarrow \frac{V}{I} \rightarrow \frac{Kg\ m^2}{A \cdot s^3}$

Resistance is clearly $\frac{\text{Voltage}}{\text{Amperage}}$ $\begin{cases} R \equiv \frac{V}{I} \\ I \equiv \frac{V}{R} \end{cases}$ $V \equiv RI$

COGITATION

comment about ~~COGNITION~~ ~~COGNITATION~~ $\boxed{\#001}$: Current and Resistance is FUN! So too will be DIRECT CURRENT CIRCUITS

Back to current density: how is it that ohm's law is defined as "current density = conductivity * electric field

if $I = nqv_d A$ and current density $J = \frac{I}{A}$, then $J = nqv_d$

C/s²

current density J : $\frac{\text{charge}}{\text{time}^2} \rightarrow \frac{A}{m^2} \Rightarrow \frac{A \cdot s}{s^2} \rightarrow \frac{A}{s}$

This is not intuitive either. The dimensions are Q/T^2 and yet the units imply $\frac{\text{current}}{\text{area}}$. current density : $\frac{\text{charge}}{s^2}$

$J \equiv I/A$!!! Is $\frac{\text{charge}}{\cancel{\text{second}}\ \text{area}} \stackrel{?}{=} \frac{\cancel{\text{coulombs}}}{\cancel{\text{second}}\ \text{second}}$ $\frac{\text{current}}{\text{area}} \stackrel{?}{=} \frac{\text{charge}}{\text{time}^2}$

$n \leftarrow \frac{N}{V}$, $nq \rightarrow \frac{Nq}{V} \rightarrow \frac{C}{m^3} \rightarrow \frac{A \cdot s}{m^3}$

$J = nqv_d \rightarrow \frac{A \cdot s}{m^3} \cdot \frac{m}{s} \rightarrow \frac{A}{m^2}$ $J = nqV$

$\underline{I = JA = nqvA}$

current density $J = nqv_d = \frac{I}{A} \Rightarrow \frac{A}{m^2} \rightarrow \frac{A \cdot s}{s^2} \rightarrow \frac{A}{s}$

1. current density is amps per second ...
2. * current density is also amps per area ...
3. current density is ~~charge~~ coulombs per second per second
4. current density is also conductivity σ * electric field E.

How is this Ohm's Law? Let's COGITATE ...

$$J = \sigma E$$

let A be area $\quad AJ = \sigma EA$

eq 2 : $\frac{\text{amps}}{\text{area}} = \frac{I}{\text{Area}} = J = \quad \therefore AJ \rightarrow A\frac{I}{A} = I$

"just" algebra here
algebra is All mighty – second only to arithmetic!

$I = \sigma EA$

$I = \sigma \frac{V}{l} A$

$\boxed{\text{now, } V = El \ (\text{remember } V \stackrel{?}{=} Ed) \quad \text{so, } E = V/l}$

here comes some reverse algebra: $I = \frac{\sigma AV}{l}$

RESISTANCE $= \frac{l}{\sigma A} \rightarrow \frac{m\ \Omega \cdot m}{m^2} \rightarrow \Omega \qquad I = \frac{V}{l/\sigma A} = \frac{V}{R}$

$\sigma \rightarrow \frac{1}{\Omega \cdot m}$

Still COGITATION #001:

$$\text{Resistance} \equiv \frac{\text{length}}{\text{conductivity} * \text{area}} \qquad R = \frac{l}{\sigma A}$$

intuitive idea "longer pipe, greater resistance to flow"

conductivity → ability to conduct (depends on material)

$$\frac{1}{\sigma} = \rho = \text{RESISTIVITY} \qquad R = \frac{l}{\sigma A} = \rho \frac{l}{A} \rightarrow \frac{V}{I} \rightarrow \Omega$$

$$I = V/R \Rightarrow \text{"flow rate"} = \frac{\text{voltage}}{\text{resistance}} \leftarrow \text{blockage}$$

* Ohm's Law is not a fundamental law — it only applies to most metals (ohmic materials)

—

COGITATION #002: Resistance and Temperature

$$\rho_T = \rho_{T_0}\left[1 + \alpha(T - T_0)\right]$$

where α is the "temperature coefficient of resistivity"

$$R_T = R_{T_0}\left[1 + \alpha(T - T_0)\right]$$

COGITATION #003: Electric Energy and Power

$$P = \frac{\Delta U}{\Delta t} = \frac{\Delta Q V}{\Delta t} = IV \rightarrow \text{Power} \equiv \text{current} * \text{voltage}$$

$V = RI$, $I = V/R$, $R = V/I$

$$P = IV = \frac{V^2}{R} = I^2 R$$

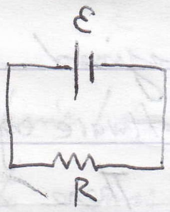
* Review these 3 cogitations Wednesday night (27th → 28th)

COGITATION #004: a source of energy → emf (ee-em-ef) from the "historical, but inaccurate", term electromotive force

A source of emf is any device that produces an electric field and thus may cause charges to move around a circuit.

An emf is a "charge pump" (battery, generator)

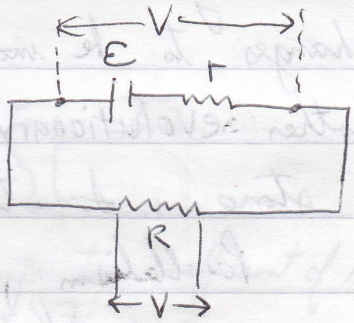
The emf, $\mathcal{E}$, describes the work done per unit charge, and hence the SI unit is the volt. ($V \rightarrow J/C$)



$I = \dfrac{\mathcal{E}}{R} = \dfrac{V}{R}$ really, $I = \dfrac{\mathcal{E}}{R+r}$

note that $\mathcal{E} = V + Ir$ where r is the internal resistance

Usually r is so small that it can be neglected



COGITATION #005: Resistors in Series and Parallel

In series	In parallel
~~With capacitance parallel V_1 V_2 V Q_1 Q_2 Q~~	With capacitance
$I_1 = I_2 = I$	$V = V_1 = V_2$ (same as Capacitance)
$V_1 + V_2 = V$ (same as Capacitance)	$I_1 + I_2 = I$
$V_1 = IR_1$, $V_2 = IR_2$	$I_1 = V/R_1$, $I_2 = V/R_2$
$I(R_1 + R_2) = V$	$I = V\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$
$R_1 + R_2 = \frac{V}{I} = R_{eq}$ (opposite capacitance)	$\frac{I}{V} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{R_{eq}}$ ($C_{eq} = C_1 + C_2$)

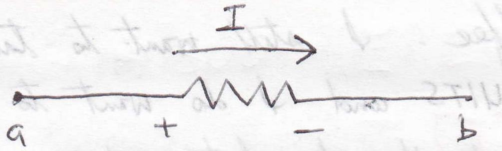
Now, I will make some coffee. I still want to tackle a few problems on DC CIRCUITS and I do want to work on a low level C version of the translator, but one more cogitation is called for. This is a big one – it is about analyzing circuits that are not simple circuits. A simple circuit has a single loop – a single emf. Very often it is not possible to reduce a circuit to a single loop. The procedure for analyzing more complex circuits is greatly simplified by the use of two simple rules called Kirchhoff's Rules.

For the next cogitation I will give those rules verbally, then I ~~we~~ will write two more cogitations – one of which will list the steps to be taken in SOLVING complex circuits.

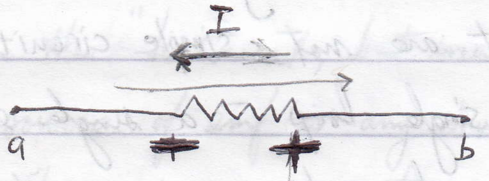
COGITATION #006: KIRCHHOFF'S RULES

- The sum of the currents entering any junction must equal the sum of the currents leaving that junction. [JUNCTION RULE]
- The algebraic sum of the changes in potential across all of the elements around any closed circuit loop must be zero. [LOOP RULE]

– The junction rule is a statement of conservation of charge, while the loop rule follows from conservation of energy. As an aid to applying the loop rule, I have listed some "sub-rules" on the next page

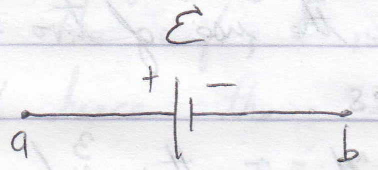


$$\Delta V = V_b - V_a = -IR$$

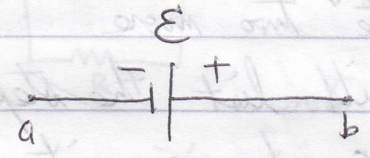


(against current)

$$\Delta V = V_b - V_a = +IR$$



$$\Delta V = V_b - V_a = -\mathcal{E}$$



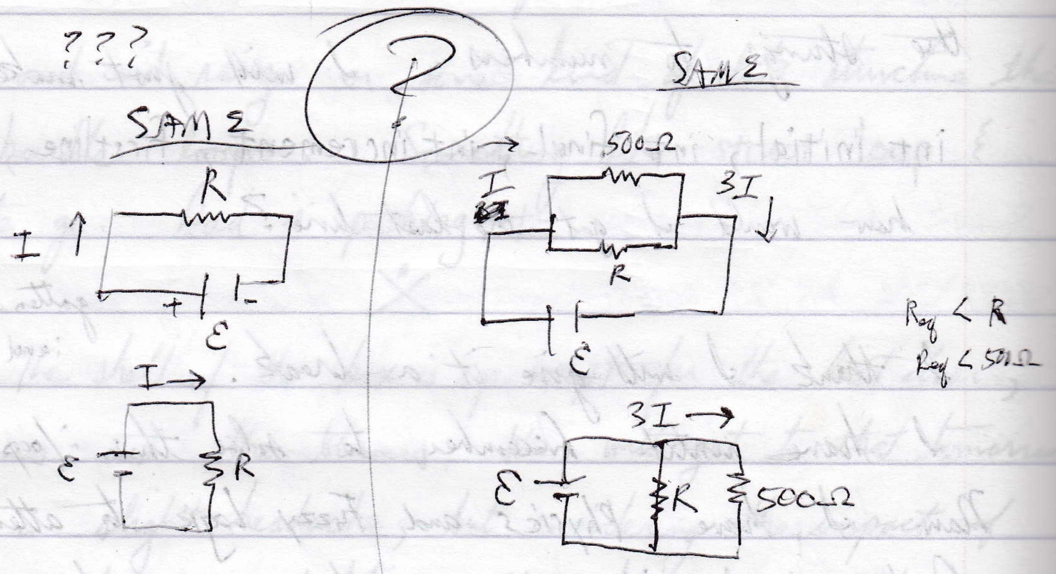
$$\Delta V = V_b - V_a = +\mathcal{E}$$

COGITATION #007 STRATEGY for using Kirchhoff's rules simply (I will explain in detail next)

1. DRAW CIRCUIT
2. ASSIGN CURRENT DIRECTION
3. LABLE RESISTORS AND VOLTAGES + and − according to 2
4. USE JUNCTION RULE
5. USE LOOP RULE

Slowly now... a current of a circuit is tripled by connecting a 500 Ω resistor in parallel with the resistance of the circuit. $R = \frac{V}{I}$ $V = \mathcal{E} = RI$ $I = \frac{V}{R}$

$I = \frac{V}{R}$???



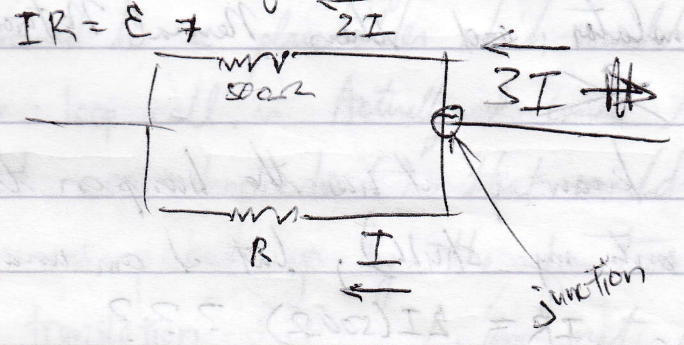
Determine the resistance of the circuit in the absence of the 500 Ω resistor.

Kirchhoff's rule (junction rule) says that

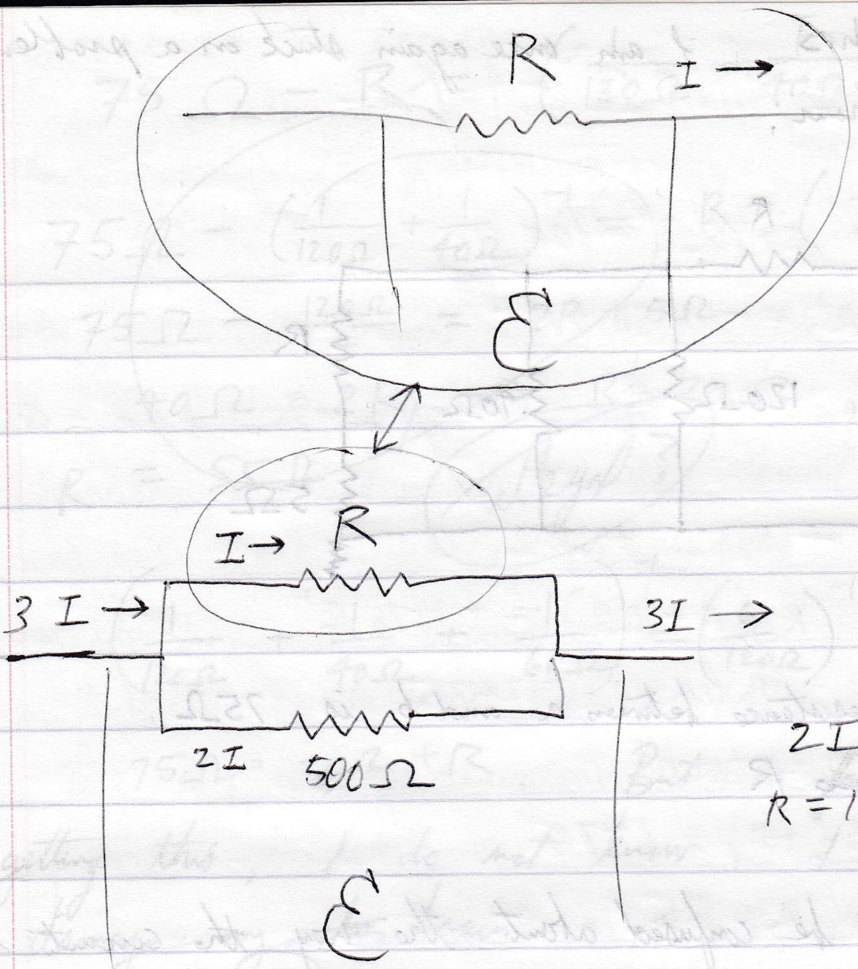
$$3I - I = 2I \Rightarrow 3I = I + 2I$$

The sum of currents entering the junction must be equal to the sum of the currents leaving the junction.

$IR = \mathcal{E}$?



$$\mathcal{E} = IR = 2I(500\,\Omega)$$



$$2I(500\,\Omega) = IR = \mathcal{E}$$
$$R = 1000\,\Omega$$

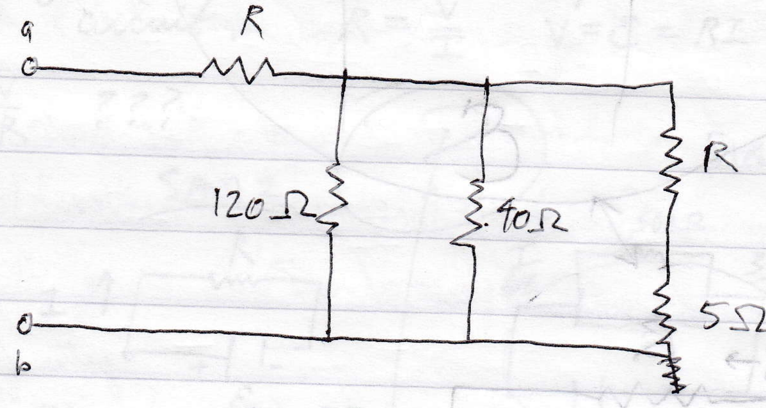
when current is I and voltage is $\mathcal{E}$, R is $1000\,\Omega$

when current is $3I$ and resistance is ~~500~~ $\left(\frac{1}{500\,\Omega} + \frac{1}{1000\,\Omega}\right)^{-1}$ $= \left(\frac{3}{1000\,\Omega}\right)^{-1} = 333\,\Omega$ and $\mathcal{E}$ is still $\mathcal{E}$.

On the split: $\mathcal{E} = IR$ and $\mathcal{E} = 2I(500\,\Omega)$

$$IR = 2I(500\,\Omega) \Longrightarrow R = 1000\,\Omega \;!$$

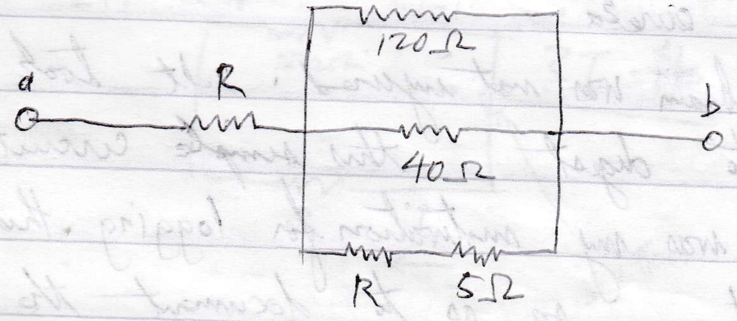
302 22:10hrs — I am once again stuck on a problem for over an hour:



total resistance between a and b is 75Ω. determine R

I seem to be confused about the way the circuit is drawn. I see that the 120Ω and 40Ω resistors are in parallel, and I am sure their equivalent resistance is in series with R; but where do R and 5Ω (in series with respect to themselves as a pair) fit in?

It helps me to draw the circuit as such:



total resistance 75Ω find R

the current going in at the junction is equal to the sum of the currents splitting 3 ways.

$$R + \left(\frac{1}{120\Omega} + \frac{1}{40\Omega} + \frac{1}{(5\Omega+R)}\right)^{-1} = 75\Omega$$

$$R = 75\Omega - \left(\frac{4}{120\Omega} + \frac{1}{5\Omega+R}\right)^{-1}$$

$$R = 75\Omega - \left(\frac{20\Omega+4R+120\Omega}{600\Omega^2+120R\Omega}\right)^{-1} = 75\Omega - \frac{600\Omega^2+120R\Omega}{140\Omega+4R}$$

$$\cancel{R = 454000\Omega^2 + 9000R\Omega^2}$$

$$R = \frac{10500\Omega^2 + 300R\Omega - 600\Omega^2 - 120R\Omega}{140\Omega + 4R}$$

$$R = \frac{9900\Omega^2 + 180R\Omega}{140\Omega + 4R} \Rightarrow 140R\Omega + 4R^2 = 9900\Omega^2 + 180R\Omega$$

$$4R^2 = 9900\Omega^2 + 40R\Omega$$

the current going in at the junction is equal to the sum of the currents splitting 3 ways.

$$R + \left(\frac{1}{120\Omega} + \frac{1}{40\Omega} + \frac{1}{(5\Omega + R)}\right)^{-1} = 75\Omega$$

$$R = 75\Omega - \left(\frac{4}{120\Omega} + \frac{1}{5\Omega + R}\right)^{-1}$$

$$R = 75\Omega - \left(\frac{20\Omega + 4R + 120\Omega}{600\Omega^2 + 120R\Omega}\right)^{-1} = 75\Omega - \frac{600\Omega^2 + 120R\Omega}{140\Omega + 4R}$$

$$\cancel{R = \frac{454000\Omega^2 + 9000R\Omega^2}{}}$$

$$R = \frac{10500\Omega^2 + 300R\Omega - 600\Omega^2 - 120R\Omega}{140\Omega + 4R}$$

$$R = \frac{9900\Omega^2 + 180R\Omega}{140\Omega + 4R} \Rightarrow \begin{aligned} 140R\Omega + 4R^2 &= 9900\Omega^2 + 180R\Omega \\ 4R^2 &= 9900\Omega^2 + 40R\Omega \end{aligned}$$

$$4R^2 = 9900\Omega^2 + 40R\Omega$$

$$R^2 = 2475\Omega^2 + 10R\Omega$$

$$2475\Omega^2 = -10R\Omega + R^2$$

$$2475\Omega = -10R + \frac{R^2}{\Omega} \Rightarrow \frac{R^2}{\Omega} - 2475\Omega + 10R = 0$$

$$R^2 - 2475\Omega^2 + 10R\Omega = 0$$

$$R(R - 10\Omega) = +2475\Omega^2$$

$$R(R-10) = 2475$$

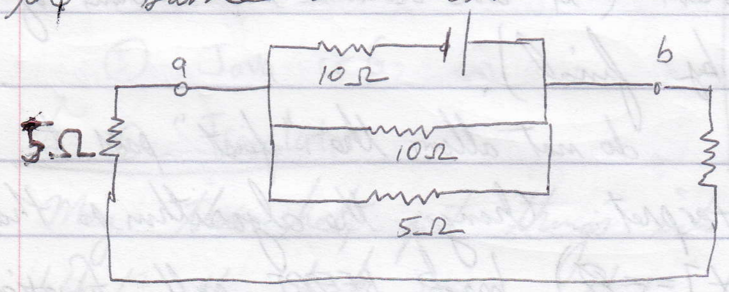
notes: $50^2 = 2500$

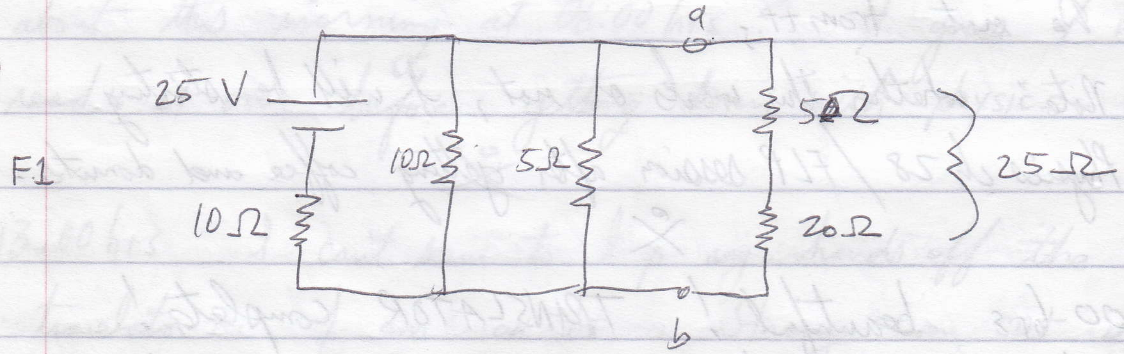
$55(45) = 2475$

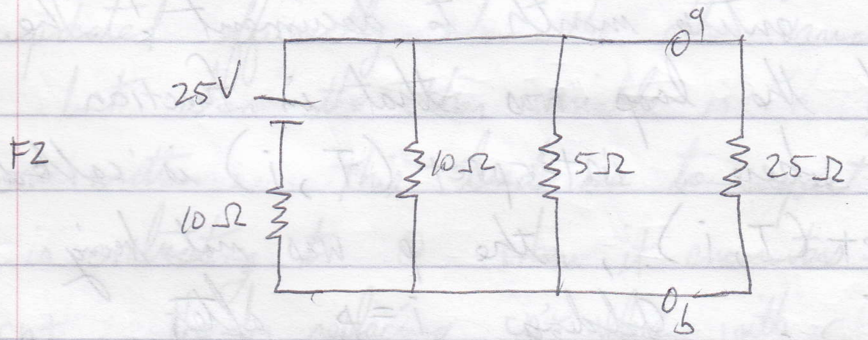
$R = 55$

304 16:30 hrs At this point, it would be prudent to rush through the physics problems; but, before I get into Kirchhoff's rules, I want to make sure I understand (grok) resistance in simple circuits.

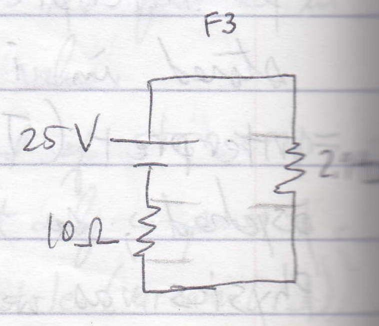
First, note that the following two circuits are the same: ① = ②

① 

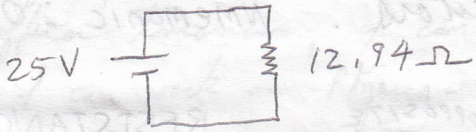
② 



$$\left(\frac{1}{10\Omega}+\frac{1}{5\Omega}+\frac{1}{25\Omega}\right)^{-1}=\frac{50\Omega}{17}=2.94\,\Omega$$



and obviously this becomes



Now, Cogito works in reverse with $I = V/R$ and $V = IR$: $I = V/R = 25V / 12.94\Omega = 1.93A$

note F3: this 1.93A current goes through the 2.94Ω resistor.

Why? In ~~series~~ every diagram, currents are equal through resistors in series

note F2: Voltage drop $V = RI = (1.93A)(2.94\Omega) = 5.7V$ is the same for the resistors in parallel.

Proof: $V = RI$; $I = I_1 + I_2 + I_3$

for F3: $V_{10\Omega} = (10\Omega)(1.93A) = 19.3V$; $19.3V + 5.7V = 25V$ ✓

for F2: $5.7V = (10\Omega)(I_1) = (5\Omega)(I_2) = (25\Omega)(I_3)$

$$\left.\begin{aligned} I_1 &= \frac{5.7V}{10\Omega} = 0.57A \\ I_2 &= \frac{5.7V}{5\Omega} = 1.14A \\ I_3 &= \frac{5.7V}{25\Omega} = 0.23A \end{aligned}\right\} \begin{array}{r} +0.57A \\ +1.14A \\ +0.23A \\ \hline 1.94A \end{array} \longleftrightarrow I = 1.93A$$

for resistors in parallel $I = I_1 + I_2 + I_3$

$R_1 I_1 = R_2 I_2 = R_3 I_3 = V$

The current through the 25Ω resistor is 0.23A

What is the current through the 20Ω resistor?

In series, $I_1 = I_2 = I$. $I = 0.23A\ ! = I_{20} = I_5$

Is this clear? $V_1 = R_1 I$, $V_2 = R_2 I$

and $V = I(R_1 + R_2) = V_1 + V_2$ [very clear Cogito]

What to remember: With resistors in series $I_1 = I_2 = I$, $V_1 + V_2 = V$

With resistors in parallel $V_1 = V_2 = V$, $I_1 + I_2 = I$.

This gets a little tricky mostly because it is opposite with capacitors. Nmemonic: OSS

OPPOSITE C-R
SAME V
SIMILAR Q I

CAPACITANCE — OPPOSITE — RESISTANCE

$$C_{eq} = C_1 + C_2 + C_3 \quad \xleftrightarrow{\text{PARALLEL}} \quad R_{eq} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)^{-1}$$

$C \equiv \frac{Q}{V}$

$$V_1 = V_2 = V_3 = V \quad \xleftrightarrow{\text{SAME}} \quad V_1 = V_2 = V_3 = V$$

$$Q_1 + Q_2 + Q_3 = Q \quad \xleftrightarrow{\text{SIMILAR}} \quad I_1 + I_2 + I_3 = I$$

$$C_{eq} = \left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right)^{-1} \quad \xleftrightarrow[\text{OPP}]{\text{SERIES}} \quad R_{eq} = R_1 + R_2 + R_3$$

$$V_1 + V_2 + V_3 = V \quad \xleftrightarrow{\text{SAME}} \quad V_1 + V_2 + V_3 = V$$

$$Q_1 = Q_2 = Q_3 = Q \quad \xleftrightarrow{\text{SIMILAR}} \quad I_1 = I_2 = I_3 = I$$

There really is not much to remember here. With nmemonic, OSS, I would only need to memorize one situation and the rest would follow. Which is most intuitive, most easily grokked? • "eq-V-IQ" ⟹ "OSS" → equiviq-OSS

I think that the junction rule makes resistors in parallel's $I_1 + I_2 + I_3 = I$ most intuitive. It remains only to memorize that for resistors in parallel $R_{eq} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)^{-1}$ and $V_1 = V_2 = V_3 = V$. With OSS, capacitors in parallel $C_{eq} = C_1 + C_2 + C_3$, and $Q_1 + Q_2 + Q_3 = Q$. |eekwivickoss| — an MvH mnemonic

307 23:45 hrs I created micronotes for chapters 27 and 28. Now, instead of rewriting them here, I will rewrite them in my Notebook for Physics — Brainware 8. I will make notes that will be helpful for the quiz problems. There are four equations that I will rewrite here: those for charging and discharging a capacitor.

$\boxed{\text{Charging a capacitor}}$

at $t=\emptyset$ switch is closed in this instant ($q_0=\emptyset$, $I_0=\frac{\mathcal{E}}{R}$)

note that $\mathcal{E}-IR-\frac{q}{C}=\emptyset$, hence — when $q=\emptyset$, it follows that $\mathcal{E}=I_0R$ and $I_0=\mathcal{E}/R$. When charged to max Q, $q=Q=C\mathcal{E}$ and $I_{final}=\emptyset$. Notice $\mathcal{E}-IR-\frac{q}{C}=\emptyset \Rightarrow \mathcal{E}=\frac{Q}{C}$ and $Q=C\mathcal{E}$

$\therefore$ $q(t)=C\mathcal{E}\left[1-e^{-t/RC}\right]=Q\left[1-e^{-t/RC}\right]$

and $I(t)=\frac{\mathcal{E}}{R}e^{-t/RC}=I_0e^{-t/RC}$

WORK DONE

$\boxed{Q\mathcal{E}=C\mathcal{E}^2 \quad \text{note: } CV^2=U}$

$\boxed{\text{Discharging a capacitor}}$

when switch is open: $V=\frac{Q}{C}$ across capacitor and $V=\emptyset$ across the resistor since $I=\emptyset$ ($V_{accross\ resistor}=IR$).

at $t=\emptyset$, switch is closed, and the capacitor begins to discharge through resistor with potential drop $V=IR=\frac{q}{C}$

at $t=\emptyset$, $q=Q=C\mathcal{E}$

$q(t)=Qe^{-t/RC}$

$I(t)=\frac{Q}{RC}e^{-t/RC}=I_0e^{-t/RC}$

$I_0=\frac{\mathcal{E}}{R}$ charge

$I_0=\frac{Q}{RC}$ dis

$\frac{C}{s}\rightarrow\frac{A\cdot s}{s}$

$C\mathcal{E}=Q$

$\frac{\mathcal{E}}{R}=I$

$\mathcal{E}-IR-q/C=\emptyset$

differences:

		CHARGING	DISCHARGING	
$Q=C\mathcal{E}$	$q(t)$	$C\mathcal{E}\left[1-e^{-t/RC}\right]$	$Qe^{-t/RC}$	
	$I(t)$	$\frac{\mathcal{E}}{R}e^{-t/RC}$ $I_0=\frac{\mathcal{E}}{R}$	$\frac{Q}{RC}e^{-t/RC}$	$I_0=\frac{Q}{RC}$

1999 308 TH 4 NOVEMBER 01:00 hrs

notice the beauty of mathematics:

from $I = \frac{\mathcal{E}}{R+r} \Longrightarrow \mathcal{E} = I(R+r)$

$\mathcal{E} = IR + Ir$ where $IR = V_{terminal}$

$\therefore \mathcal{E} = V + Ir$

insert this in the original $I = \frac{\mathcal{E}}{R+r} \Rightarrow I = \frac{V+Ir}{R+r}$

$I(R+r) = V + Ir \Longrightarrow R+r = \frac{V}{I} + r$

$I = \frac{V+Ir}{R+r}$ instead, let's note that $I = \frac{V}{R}$

$$I = \frac{V + \frac{Vr}{R}}{R+r} \cdot \frac{R}{R} = \frac{VR+Vr}{R(R+r)} = \frac{V(R+r)}{R(R+r)}$$

and hence, $I = \frac{V}{R}$ ... not magic; math!

$R = \frac{V}{I}$

308 02:15 hrs Here's another one — one last one before I crash: $r = \frac{V\mathcal{E}}{P} - R$

how? $\mathcal{E} = V + Ir \therefore r = \frac{\mathcal{E} - V}{I} = \frac{\mathcal{E}}{I} - \frac{V}{I}$

$\therefore r = \frac{\mathcal{E}}{I} - R$ $\quad P = IV \therefore I = \frac{P}{V}$

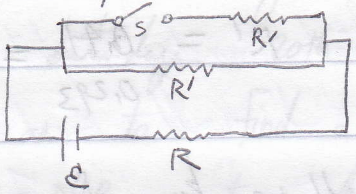
$$r = \frac{\mathcal{E}}{P/V} - R = \frac{\mathcal{E}V}{P} - R = r$$

I will try to get up around 11:00hrs so as to go over a few DC circuits and Kirchhoff rules before going over to the college for the Physics lecture. I am doing very well.

03:00hrs Let's see. If I sleep from 3:30 to 10:30 — that is a full 7 hours sleep. I will shower and then drink coffee while spending a good hour going over Physics problems. 3AM is where I draw the line. No more physics for tonight, but I would like to read for pleasure some of my own writings.

308 10:50 hrs right on schedule... out of bed by 10:30 and showered and drinking coffee by 11:00. The problem Cogito was focusing on during slumber makes use of the math on p.100 herein.

The problem states that the power dissipated in the top part of the circuit does not depend on whether the switch is open or closed:



$R = 1\,\Omega$

Power dissipated $P = IV$ and $V = IR$ $\therefore$ $P = I(IR) = I^2R$

when open $P = I^2 R'$ where $I = \frac{\varepsilon}{R+R'}$ because ~~in series~~ we take R and R' in series $(R+R')$.

hence $P = \left(\frac{\varepsilon}{R+R'}\right)^2 R' = \frac{\varepsilon^2 R'}{(R+R')^2}$

when closed the two resistors, R' and R' are added in parallel — yielding $\left(\frac{1}{R'}+\frac{1}{R'}\right)^{-1} = \left(\frac{2}{R'}\right)^{-1} = \frac{R'}{2}$, hence $P' = \left(\frac{\varepsilon}{R+\frac{R'}{2}}\right)^2 \frac{R'}{2}$

$P' = \frac{\varepsilon^2 \frac{R'}{2}}{(R+\frac{R'}{2})^2}$. Now $P = P'$ and we solve for R' (R prime)

Is that/this tricky, solving for R'? Yes, and although I want to move ahead, I will do the math here for practice.

$$P = P'$$

$$\frac{\mathcal{E}^2}{(R+R')^2} R' = \frac{\mathcal{E}^2}{(R+\frac{R'}{2})^2} \frac{R'}{2}$$

$$\frac{1}{(R+R')^2} = \frac{1}{2(R+R'/2)^2}$$

$$(R+R')^2 = 2\left(R+\frac{R'}{2}\right)^2$$

$$R+R' = \pm\left(\sqrt{2}\left(R+\frac{R'}{2}\right)\right)$$

$$R+R' = \sqrt{2}R + \frac{\sqrt{2}}{2}R' = 1.41R + 0.707R'$$

given: $R = 1\Omega$ $\qquad R'(1-0.707) = R(1.41-1)$

$$R' = \frac{0.41}{0.293} = 1.4\,\Omega$$

we can prove this? If we know $\mathcal{E}$. Can we find $\mathcal{E}$ given $R' = 1.4\Omega$ and $R = 1\Omega$? We don't know current or emf

check it out ... the voice in my head --- Xiaoxiang Liu's ... saying ... ok, next problem ... whats next? go. ...

note: I called Offcampus Housing at Rutgers: the average cost for a studio apartment is \$600/month and for single room in a house is \$400/month. I will start looking this week.

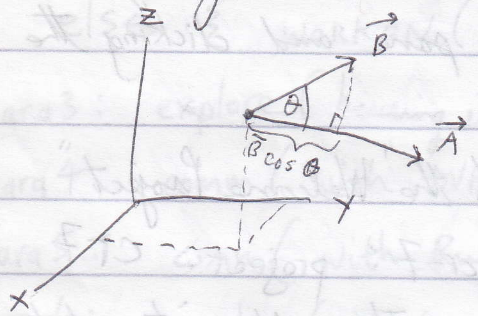
310 22:30 hrs The basic shell of cr-7 is built. I will get back into it tomorrow night; I will get into cr-8 after the next Physics exam (which will be around November 10th) I will have plenty of time to dabble.

For the rest of the evening, while watching Mad TV + SNL and into the twilight, I will explore (electromagnetism)

22:50hrs: COGITATION #008 Vector Multiplication

Dot Product (scalar product)

$\vec{A} \cdot \vec{B} \equiv |\vec{A}||\vec{B}| \cos\theta$ where $\theta \equiv \angle \frac{B}{A}$ is the smallest angle between vectors $\vec{A}$ and $\vec{B}$



$|\vec{B}| \cos\theta$ equals the scalar projection of $\bar{B}$ onto $\bar{A}$

example of use: $\text{work} = |\vec{F}||\vec{l}| \cos\theta = \vec{F} \cdot \vec{l}$

N m Joules

$\vec{A} \cdot \vec{B} = (A_x \vec{i} + A_y \vec{j} + A_z \vec{k}) \cdot (B_x \vec{i} + B_y \vec{j} + B_z \vec{k})$

$\vec{A} \cdot \vec{B} = A_x B_x + A_y B_y + A_z B_z$

$|\vec{B}| \cos\theta = \dfrac{\vec{A} \cdot \vec{B}}{|\vec{A}|}$ scalar projection of $\vec{B}$ onto the direction of $\vec{A}$

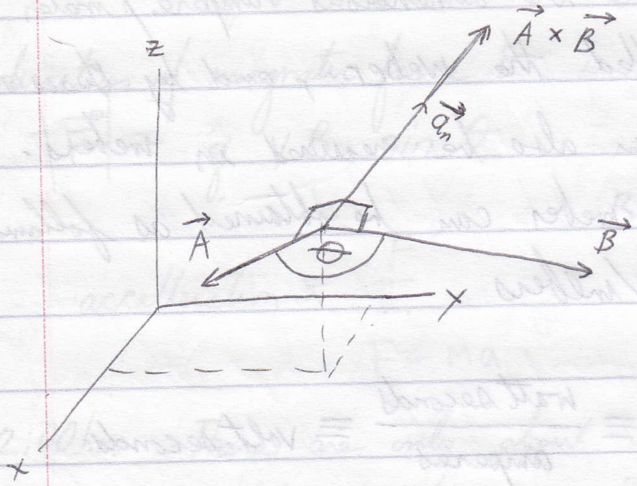
$|\vec{A}| \cos\theta = \dfrac{\vec{A} \cdot \vec{B}}{|\vec{B}|}$ scalar projection of $\vec{A}$ onto the direction of $\vec{B}$

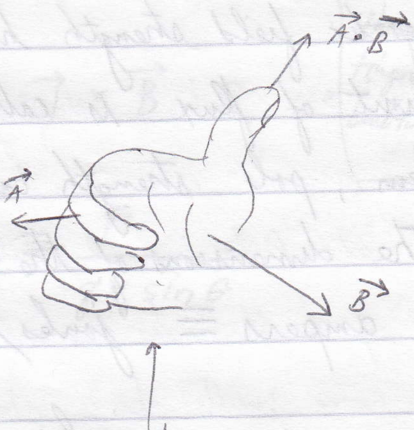
hence $\theta = \cos^{-1}\left[\frac{\vec{A}\cdot\vec{B}}{|\vec{A}||\vec{B}|}\right]$

COGITATION #009 Vector Multiplication (Vector Product)

CROSS PRODUCT

$$\vec{A}\times\vec{B} \equiv \vec{a}_n\,|\vec{A}||\vec{B}|\sin\theta \qquad \theta = \sin^{-1}\left[\frac{|\vec{A}\times\vec{B}|}{|\vec{A}||\vec{B}|}\right]$$





Right hand rule

$$\vec{A}\times\vec{B} = -\vec{B}\times\vec{A}$$

$$\vec{A}\times\vec{B} = (A_yB_z - A_zB_y)\vec{i} + (A_zB_x - A_xB_z)\vec{j} + (A_xB_y - A_yB_x)\vec{k}$$

$\vec{i} \rightarrow$ x direction $\vec{j} \rightarrow$ y-direction $\vec{k}$: z direction

in determinant form

$$\vec{A}\times\vec{B} = \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix} \begin{matrix} \\ A_x \\ B_x \end{matrix}$$

$\begin{matrix} A_y & A_z \\ B_y & B_z \end{matrix} \rightarrow (A_yB_z - A_zB_y)\vec{i}$

$\begin{matrix} A_z & A_x \\ B_z & B_x \end{matrix} \rightarrow (A_zB_x - A_xB_z)\vec{j}$

$\begin{matrix} A_x & A_y \\ B_x & B_y \end{matrix} \rightarrow (A_xB_y - A_yB_x)\vec{k}$

111 1999 311 SU 07 NOVEMBER 01:00 hrs

I went through the two books from the campus library on Electromagnetism but the notation is too obscure. I will focus on the main text after a cogitation about the units of measurement for magnetic flux density.

COGITATION #010 The tesla (T)

Magnetic field strength has the dimensions ampere / meter. The unit of flux is called the weber, and by Guass's theorem, pole strength can also be measured in webers.

The dimensions of the weber can be obtained as follows:

$$\text{ampers} \equiv \text{joules/webers}$$

$$\therefore \quad \text{webers} \equiv \frac{\text{joules}}{\text{amperes}} \equiv \frac{\text{watt seconds}}{\text{amperes}} \equiv \text{volt seconds}$$

An alternative way in terms of the four primary quantities is to write $\text{weber} \equiv \dfrac{\text{joules}}{\text{amperes}} \Longrightarrow \dfrac{kg \; m^2}{s^2 A}$ note: $J \to N \cdot m \to \dfrac{kg \, m^2}{s^2}$

Wb/m^2: weber per square meter

SI unit of the magnetic field $\dfrac{Wb}{m^2} \to \dfrac{kg \, m^2}{s^2 A m^2} \to \dfrac{kg}{s^2 A}$

$$[B] \equiv \text{Magnetic Field} \equiv T = \frac{Wb}{m^2} = \frac{N}{C \cdot m/s} = \frac{N}{Am}$$

non SI unit: gauss $1T = 10^4 G$

$$N \to \frac{kg \, m}{s^2}, \quad \therefore \frac{N}{C \frac{m}{s}} = \frac{N}{A \cdot s \frac{m}{s}} = \frac{N}{Am} \leadsto \frac{\frac{kg \, m}{s^2}}{A \cdot m} = \frac{kg \, m}{A s^2} = \frac{N}{A \cdot m}$$

The tesla is a weber per square meter $\frac{Wb}{m^2}$
This is the unit of measurement for Magnetic fields.

$$1\,T = 1\,\frac{N \cdot s}{C \cdot m} = 1\,\frac{N}{A\,m}$$

COGITATION #011 MAGNETIC FORCE vs MAGNETIC FIELD

$$\vec{F} = q\vec{v} \times \vec{B}$$

thumb F
fingers v
bent fingers B

direction of magnetic force F is $\vec{v} \times \vec{B}$

$$|\vec{F}| = q\,vB\sin\theta$$

$$B \equiv \frac{F}{qv\sin\theta}$$

$$\text{accelleration} = \frac{F}{m}$$

$$F = ma$$

02:00hrs There are only about 3 ch 29 problems that I might be able to attempt before Tuesday's lecture, and I really don't want to screw up the shell of cr 7 that I have already constructed (as it is late...). Hence, I can relax and read VISIONS by Michio Kaku. I was reading last night (around 04:00 hrs) about how an advanced civilization would demand more energy than their planet could possibly supply, so they use their sun. Once they exhaust the single star, they go into the galaxy to harness more energy. There is something hauntingly despiritualized about it. Are we some kind of energy sucking leeches on the earth? VISIONS it is.

COGITATION #012 : Properties of the magnetic force on a charge moving in a B field.

- The magnitude of the magnetic force is proportional to the charge q and speed v of the particle.
- The magnitude and direction of the magnetic force depend on the velocity of the particle and on the magnitude and direction of the magnetic field.
- When a charged particle moves parallel to the magnetic field vector, the magnetic force on the charge is zero.
- When the velocity vector makes an angle θ with the magnetic field, the magnetic force acts in a direction perpendicular to both v and b; that is, F is $\perp$ to the plane formed by v and B.
- The magnetic force on a positive charge is in the direction opposite the direction of the force on a negative charge moving in the same direction.
- IF the velocity vector makes an angle θ with the magnetic field, the magnitude of the magnetic force is proportional to $\sin\theta$.

These observations can be summarized by writing the magnetic force in the form $\vec{F} = q\vec{v} \times \vec{B}$

See cogitation #013 for the differences between the electric force and the magnetic force.

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See cogitation #013 for the differences between the electric force and the magnetic force.

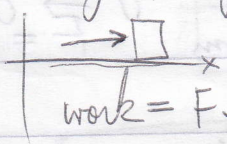
311 13:40hrs. A book I will be taking some notes from will also be investigated during the interval between December 23rd and January 15th. I will look over Linear Algebra and it's Applications in preparation for Intro to Lin Alg 640:250 at Rutgers. I suspect that I will be totally into that class as I love solving systems of equations and I will immediately apply the techniques I am taught.

COGITATION #013 : F_e vs F_M

- The electric force is always in the direction of the electric field, whereas the magnetic force is perpendicular to the magnetic field. $\vec{F}_e \parallel \vec{E}$, $\vec{F}_M \perp \vec{B}$

- The electric force acts on a charged particle independent of the particle's velocity, whereas the magnetic force acts on a charged particle only when the particle is in motion.

- The electric force does work in displacing a charged particle, whereas the magnetic force associated with a steady magnetic field does no work when a particle is displaced.
  This is because magnetic force is perpendicular to the displacement:



work = $F x \cos\theta$ $\quad\quad$ $\cos 90° = 0$

COGITATION #014 : COGITATION #009 REVISITED (p111)

$\vec{F} = q\vec{v}\times\vec{B}$, although it defines magnetic force, also serves as the definition of magnetic field vector $\vec{B}$.

In cog_9 I used $\vec{A}\times\vec{B}$. Here I will use $\vec{v}\times\vec{B}$

$$\vec{v}\times\vec{B} = \begin{matrix} \vec{K} \\ \\ \\ \end{matrix}\begin{vmatrix} \vec{i} & \vec{j} & \vec{K} \\ V_x & V_y & V_z \\ B_x & B_y & B_z \end{vmatrix}\begin{matrix} \\ V_x \\ B_x \end{matrix}$$

"very Buzy"

$$\vec{v}\times\vec{B} = \vec{i}\left(v_y B_z - v_z B_y\right) + \vec{j}\left(v_z B_x - v_x B_z\right) + \vec{k}\left(v_x B_y - v_y B_x\right)$$

This means that the components of the magnetic force are:

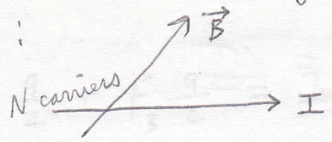
$$\left.\begin{aligned} F_x &= q\left(v_y B_z - v_z B_y\right) \\ F_y &= q\left(v_z B_x - v_x B_z\right) \\ F_z &= q\left(v_x B_y - v_y B_x\right) \end{aligned}\right\} \left|\vec{F}_M\right| = \sqrt{F_x^2 + F_y^2 + F_z^2}$$

MAGNITUDE OF MAGNETIC FORCE

direction of $\vec{F}_M$: use right hand rule

where does $\vec{F} = q\vec{v}B\sin\theta$ come in where F is magnitude?

COGITATION #016 Magnetic Force on a "current-carrying" conductor :



current I is as moving charge
where N is the number of charge carriers
I is "rate of flow"

for a charge : $F_B = qvB\sin\theta$

for a current $F_B = NqvB\sin\theta$

$$n \rightarrow \text{"carrier density"} = \frac{N}{V} \rightarrow \frac{\text{number of carriers}}{\text{area} * \text{length}}$$

$N \rightarrow$ number of carriers $\Rightarrow (nAl) \rightarrow$ carrier density $*$ volume

$\therefore \quad F_B = (nAl)qvB\sin\theta$ where $nAqv = I$

see cogitation #001 p.62 to 65 : $\Delta Q = Nq = (nA\Delta x)q$

$$I = \frac{\Delta Q}{\Delta t} = \frac{nA\Delta x\, q}{\Delta t} = nAvq \quad : \quad N = nV = (nA\Delta x)$$

again $F_B = NqvB\sin\theta = nAl\,qvB\sin\theta = \boxed{I\,l\,B\sin\theta}$

where $I = nAqv$

For a straight wire in a uniform magnetic field,

$$\vec{F}_B = I\,\vec{l} \times \vec{B}$$

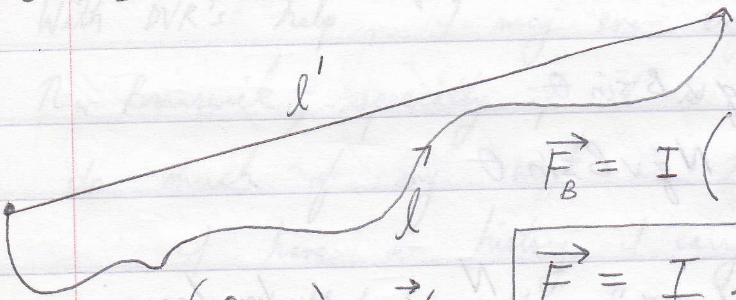
Here, we treat length as a vector, where the direction of $\vec{l}$ is the currents direction and current is a scalar.

In general, even if the wire is not straight,

$$\vec{F}_B = \int I\,d\vec{l} \times \vec{B}$$

$$\vec{F_B} = \int I \, d\vec{l} \times \vec{B}$$

case 1: $\vec{B}$ is constant



displacement is l'

wire is l

$$\vec{F_B} = I\left(\int d\vec{s}\right) \times \vec{B}$$

$$\left(\int d\vec{s}\right) = \vec{l}' \qquad \boxed{\vec{F_B} = I\,\vec{l}' \times \vec{B}}$$

if wire is straight $l = l'$

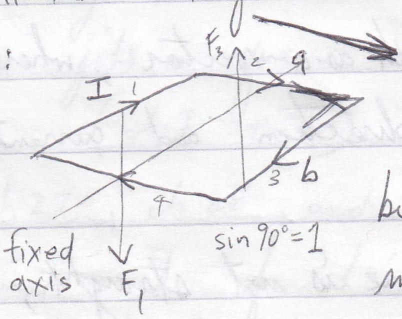
case 2: $\vec{B}$ is still constant but wire is a loop

$\vec{F_B} = \emptyset$ because displacement is zero

$\vec{B}$ doesn't change. If a loop is put in the magnetic field $\vec{B}$, there is no magnetic force $\vec{F_B}$ ...

... but, there is torque, τ

COGITATION #017 Torque on a current loop in a uniform magnetic field:



$\vec{F_B} = \emptyset$ ∴ no linear motion but it can have rotational motion caused by torque.

$\boxed{F_B = I l B \sin\theta}$

$F_1 = IbB$ (down)

$F_2 = \emptyset$

$F_3 = IbB$ (up)

$F_4 = \emptyset$

$$\vec{F_B} = \emptyset \;\therefore\; \vec{F_B} = F_1 - F_3$$

TORQUE $\tau = Fr \sin\theta = I\vec{A}\times\vec{B}$

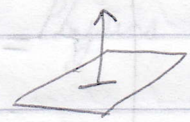
where $r = \frac{a}{2}$
$\theta = 90°$
$\sin 90° = 1$

$$\tau = F_1 \frac{a}{2} + F_3 \frac{a}{2} = \frac{IabB}{2} + \frac{IabB}{2} = IabB = IAB$$

if more than one loop $\tau_{MAX} = NIAB$

magnetic moment $= \mu = IA \therefore \tau = \vec{\mu}\times\vec{B}$

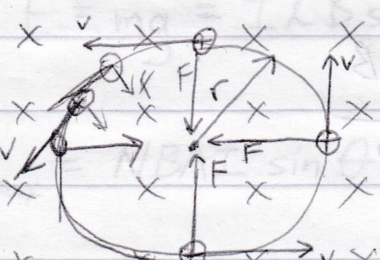
surface direction $\hat{n}$



surface direction is direction of thumb as you wrap four fingers around the current.

$$\vec{\tau} = \vec{\mu}\times\vec{B} = NI\,\vec{A}\times\vec{B}$$

COGITATION #Ø18 Motion of a charged particle in a UNIFORM magnetic field



$\otimes \vec{B}$ IN

speed, v, does not change as $\vec{F_B}$ cannot make speed change. $\vec{F_B}$ changes $\vec{v}$'s direction.

tension = centripetal force = magnetic force

$$F_c = F_B$$

$$m\frac{v^2}{r} = qvB$$

$$\frac{mv}{r} = qB$$

$$r = \frac{mv}{qB}$$

Time Period $T = \frac{2\pi r}{v}$ (the time for one revolution) $\frac{m}{\frac{m}{s}} = s$

$v = \frac{2\pi r}{T} \therefore T = \frac{2\pi}{v}\left(\frac{mv}{qB}\right) = \frac{2\pi m}{qB}$

$f = \frac{1}{T}$ FREQUENCY
$\omega = 2\pi f = \frac{2\pi}{T}$

ω is "angular frequency of the rotating charged particle",

$$\omega = \frac{v}{r} = \frac{qB}{m} \qquad \omega = \frac{2\pi}{T}$$

$$T = \frac{2\pi r}{v}$$

I will write this again:

$$F_c = F_B$$

$$\frac{mv^2}{r} = qvB$$

$$\frac{mv}{r} = qB$$

$$r = \frac{mv}{qB}$$

$$\text{velocity} = \frac{\text{distance one rev}}{\text{time one reve}} = \frac{2\pi r}{T}$$

$$\therefore\ T = \frac{2\pi r}{v} = \frac{2\pi}{v}\left(\frac{mv}{qB}\right) = \frac{2\pi m}{qB}$$

$$\therefore\ \omega = \frac{2\pi}{T} \longrightarrow \frac{2\pi}{\frac{2\pi m}{qB}} = \frac{qB}{m}$$

19:00hrs This logbook leans towards the Brainwaves more than the Meditations of a Hermit — but I am still like a hermit... This semester at Brookdale is the best one since C++, Data Structures, Psychology, Anthropology. It is even better because JAVA is my C++, OST is my Data Structures and PHYSICS II is the most awesome MATH/SCIENCE class I have ever taken. Before Sunday I will complete my study sheet. I will most likely finish cr-8 over the weekend, but I will stay focused on ch 29 Wednesday night, all day Thursday, Fri/Sat nights.

COGITATION #019: $\sum F = ma = F_e + F_B = qE + F_B$

$\therefore F_B = \sum F - F_e = ma - qE = F_B$

$$F = mg = I l B \sin\theta \Rightarrow \frac{m}{l} g = I B \sin\theta$$

$\tau_{max} = NBAI \sin\theta$ $\tau = \frac{\text{mass} * \text{accelleration}}{\text{amperage}}$

$$\tau \to \frac{m\,a}{I} \to \frac{kg}{A}\frac{m}{s^2} \to \frac{kg\ m}{s^2}\cdot\frac{1}{A} \to \frac{N}{m}\cdot\frac{1}{A} \to \frac{kg}{A\cdot s^2}$$

if $|\cancel{F_B}\,\tau| = NBAI$, then $I = \frac{\cancel{F_B}\,\tau}{NBA}$

COGITATION #020: ENERGY = WORK in joules N·m

$$J \to N\cdot m \to \frac{kg\ m^2}{s^2} \to kg\frac{m^2}{s^2} \Rightarrow \frac{1}{2} m v^2$$

$U = \frac{1}{2} m v^2 = |e| V$ $v^2 = \frac{2|e|V}{m}$ $v = \sqrt{\frac{2eV}{m}}$

$\sum F = ma \Rightarrow \frac{mv^2}{r} = evB\sin 90° \Big\{ B = \frac{mv}{er} = \frac{m}{er}\sqrt{\frac{2eV}{m}} = \frac{1}{r}\sqrt{\frac{2mV}{e}}$

$\frac{kg\ m^2/s^2}{m} = kg\frac{m}{s^2}$

319 14:15 hrs My pattern. Awake until 4AM, up at 2PM. 155

8 hours from 4AM is NOON – hence I sleep ten hours when I do this. Just making an observation. I am a slacker. Give me slack or give me death. Sleep... that's what I do when the world is awake. Wide awake I am when the world sleeps. Such is the way of my organism.

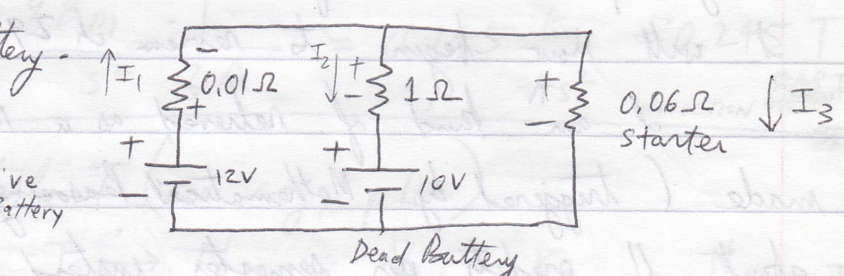
I leave for school in just 4 hours. I will go over ch 29 Physics problems. Am I a bum?

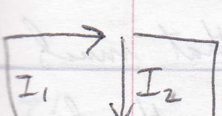
Bum is a word used by slaves. Let us focus in on the creepiness of existence. I dream of humping a young female from behind. These are common urges that are ~~thwar~~ thwarted by economics.

15:15 hrs The task at hand: Physics. I am going through problems mentally. I want to go over one in pen here in the logbook.

ch 28 #29: A dead battery is charged by connecting it to the live battery of another car. Determine the current in the starter and in the dead battery.

I have to arbitrarily choose the current directions.





L_1: $12V - 0.01\Omega I_1 - 1\Omega I_2 - 10V = \emptyset = 2V - 0.01\Omega I_1 - 1\Omega I_2$

L_2: $10V + 1\Omega I_2 - 0.06\Omega I_3 = \emptyset$

$I_1 = I_2 + I_3$

I_3 in terms of I_2: $I_3 = 10V + 1\Omega I_2 / (0.06\Omega)$

$12V - 0.01\Omega(I_2 + I_3) - 1\Omega I_2 - 10V = \emptyset$

$$2V - 0.01\Omega I_2 - 0.01\Omega I_3 - 1\Omega I_2 = \emptyset$$

$$2V - 1.01\Omega I_2 - 0.01\Omega I_3 = \emptyset$$

we know $I_3 = \dfrac{10V + 1\Omega I_2}{0.06\Omega}$ so we substitute

$$2V - 1.01\Omega I_2 - \frac{0.01\Omega}{0.06\Omega}\left(10V + 1\Omega I_2\right) = \emptyset$$

$$2V - 1.01\Omega I_2 - 1.67V - 0.167\Omega I_2 = \emptyset$$

$$2V - 1.176\Omega I_2 - 1.67V = \emptyset = 0.33V - 1.176\Omega I_2$$

$$I_2 = \frac{0.33V}{1.176\Omega} = 0.28\,A \text{ in Dead Battery.}$$

$$I_3 = \frac{10V + 1\Omega(0.28A)}{0.06\Omega} = 171.3\,A \text{ in starter.}$$

I feel much better now, writing that (solving that) in ink. I just have to watch the subscripts. I have to stay in the equation at hand while also being aware of the larger problem the equation is an algorithmic branch of. I will now begin to review ch 29.

I am kind of relieved as a result of the decision made (triggered by Mathematical Reasoning being full) to take about 11 credits per semester instead of 14 credits. Slack is good. I will be able to devout that much more time to Multivariable Calculus! Right down the line, this is going to make my daily existence more enjoyable. What is the rush? I will be 33 in February!

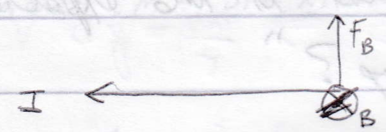
I will expound upon a part of cog 19 on p 131

COGITATION #021: mass per unit length and force mg.

"A wire having a mass per unit length of 0.5 g/cm carries a 2A current horizontally to the south. What are the direction and magnitude of the minimum magnetic field needed to lift this wire vertically upward?"

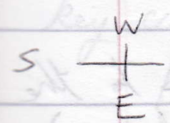
mass per unit length implies $\frac{m}{l}$, but first we must convert 0.5 g/cm to SI units kg/m:

$$\frac{m}{l} = \frac{0.5\,g}{cm} \cdot \frac{1\,Kg}{1000\,g} \cdot \frac{100\,cm}{1\,m} = \frac{0.05\,Kg}{m}$$



horizontally to the south is $\vec{I} = 2A$

⊙ EAST



$F_B = I l B \sin\theta$ must counterbalance weight $= mg$

$$\therefore mg = I l B \sin 90° = I l B$$

we know $\frac{m}{l}$, so we rearrange the equation algebraically:

$$\frac{m}{l} g = I B \text{ ; solving for } B = \frac{mg}{l I}$$

$$B = \frac{0.05\,Kg}{m} \cdot \frac{9.8\,m}{s^2} \cdot \frac{1}{2A} = 0.245 \frac{Kg}{As^2} = 0.245\,T$$

direction ~~WEST~~ EAST ⊗

---

a note about unit tesla T (see cog 10 p 112)

$$N \rightarrow \frac{kg\,m}{s^2} \qquad T \rightarrow \frac{N}{C\frac{m}{s}} \rightarrow \frac{N}{Am} \therefore \frac{Kg}{As^2} \Rightarrow \frac{N}{mA} \rightarrow T$$

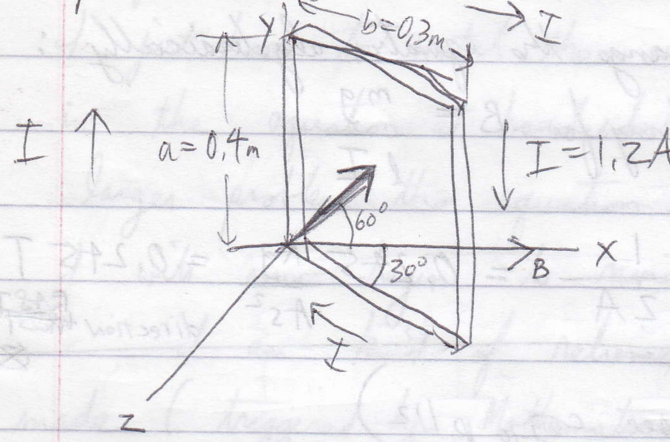
The important thing to remember is the $F_B = I l B \sin\theta$ is a force. So is weight mg. We know $\frac{m}{l}$ and I and the gravitational constant $g = 9.8 \frac{m}{s^2}$. We can solve for B (MAGNETIC FIELD)

cog_{16} to cog_{20} cover much theory. The next several cogitations will go over specific cases.

COGITATION #Ø22: "A rectangular loop consists of $N = 100$ closely wrapped turns and has dimensions $a = 0.40$ m and $b = 0.30$ m. The loop is hinged along the y-axis, and its plane makes an angle $\theta = 30°$ with the x-axis. What is the magnitude of the torque exerted on the loop by a uniform magnetic field $B = 0.80$ T directed along the x-axis when the current is $I = 1.2$ A in the direction shown? What is the expected direction of rotation of the loop?"

first. Draw a picture.

The tricky part in this problem is that the angle ⊥ to the plane makes a 60° wrt the x-axis (the magnetic field B):



$$\tau_{MAX} = NBAI \sin\theta$$

θ: torque is at 60° angle to $\vec{B}$

$N = 100$

$B = 0.8$ T

$I = 1.2$ A

$A = ab = (0.4\text{m})(0.3\text{m}) = 0.12\ \text{m}^2$

$$\therefore\ \tau = NBAI \sin 60° = (100)(0.8\text{T})(1.2\text{A})(0.12\text{m}^2)(\sin 60°) = 9.97\ \text{Nm}$$

note about units: $\text{TAm}^2 \rightarrow \left(\frac{\text{N}}{\text{A}\cdot\text{m}}\right)\left(\frac{\text{A}}{1}\right)\left(\frac{\text{m}^2}{1}\right) \rightarrow \text{Nm}$

Nm are units for torque see cog_{16} + cog_{17} p. 128-9

3/9 17:45 hrs For Tuesday and Wednesday, I may just go over my notes (in here as well as notes from lecture) in preparation for the second Physics exam.

COGITATION #Ø23: "A singly charged positive ion has a mass of 3.2×10^{-26} Kg. After being accellerated from rest through a potential difference of 833 V, the ion enters a magnetic field of Ø.920 T along a direction ⊥ to the direction of the field. Calculate the radius of the path of the ion in the field."

given $m = 3.2 \times 10^{-26}$ Kg ; $V = 833V$; $B = 0.920T$

key concept: increase in kinetic energy = change in potential energy

$K = \frac{1}{2}mv^2$ and $U = |e|V$

$|e|$ always is 1.6×10^{-19} C $\therefore |e|V = 1.33 \times 10^{-16}$ J

set this equal to $\frac{1}{2}mv^2 = 1.33 \times 10^{-16}$ J

we know mass, we solve for v.

algebraically $v^2 = \frac{2|e|V}{m} \Rightarrow v = \sqrt{\frac{2eV}{m}}$

$v = \sqrt{2(1.33 \times 10^{-16} J)/3.2 \times 10^{-26} Kg} = 9.13 \times 10^4 \frac{m}{s}$

We need to find radius r.

centripical force magnetic force

key concept: $F_c = F_B \Rightarrow \frac{mv^2}{r} = qvB$

$\frac{mv}{r} = qB \Rightarrow r = \frac{mv}{qB} = \frac{(3.2 \times 10^{-26} kg)(9.13 \times 10^4 \frac{m}{s})}{(1.6 \times 10^{-19} C)(0.920 T)}$

$r = 1.98 \times 10^{-2}$ m

We had to find velocity first in order to find radius.

The 2 key concepts can be remembered as equations.

① increase in kinetic energy = change in potential energy

$K = \frac{1}{2}mv^2$ $\qquad$ $U = |e|V$

$$\frac{1}{2}mv^2 = |e|V$$

$$v = \sqrt{\frac{2eV}{m}}$$

② centripetal force = magnetic force

$$F_c = F_B$$

$$\frac{mv^2}{r} = qvB \Rightarrow \frac{mv}{r} = qB$$

$$r = \frac{mv}{qB}$$

COGITATION #024: "A proton moving in a circular path ⊥ to a constant magnetic field takes 1 microsecond to complete one revolution. Determine the magnitude of the field." $1\,\mu s = 1 \times 10^{-6}\,s = T$ = time period

$$m_p = 1.67 \times 10^{-27}\,kg$$

$$T = \frac{2\pi m}{qB} \quad \therefore \quad B = \frac{2\pi m}{qT} = 0.0656\,T$$

---

note that T can be expressed as $T = \frac{2\pi r}{v}$. Substituting r from above $T = \frac{2\pi}{v}\left(\frac{mv}{qB}\right) = \frac{2\pi m}{qB}$. Remember $r = \frac{mv}{qB}$

Lastly for this unit of Physics, cog_{25} ties things together.

COGITATION #Ø25: "A cosmic ray proton in interstellar space has an energy of 10 MeV and executes a circular orbit having a radius equal to that of Mercury's orbit around the sun (5.8×10^{10} m). What is the magnetic field in that region of space?"

key concept: Think of the proton as having accellerated through a potential difference $V = 10^7 V$. Then its energy is $\frac{1}{2}mv^2 = eV$ and its speed is

$$v = \sqrt{\frac{2eV}{m}} \quad \left[\text{equation ① from } cog_{23}\right]$$

$$\frac{mv^2}{r} = evB\sin 90° \quad \left[\begin{array}{l}\text{equation ② from } cog_{23} \\ \text{where } q \leftarrow e \text{ and } 1 \leftarrow \sin 90°\end{array}\right]$$

hence $\frac{1}{2}mv^2 = qV$ and $\frac{mv^2}{r} = qvB\sin 90°$

$$\therefore \quad B = \frac{mv^2}{rev} = \frac{mv}{re} \quad \left[v = \sqrt{\frac{2eV}{m}}\right]$$

$$B = \frac{m}{re}\sqrt{\frac{2eV}{m}} = \frac{1}{r}\sqrt{\frac{2eVm^2}{me^2}} = \frac{1}{r}\sqrt{\frac{2Vm}{e}}$$

$$B = \frac{1}{5.8 \times 10^{10} m}\sqrt{\frac{2(10^7 V)(1.67 \times 10^{-27} kg)}{(1.6 \times 10^{-19} C)}}$$

$$B = 7.88 \times 10^{-12} \, T$$

3|9 18:20 This concludes my review of Physics ch 27 to ch 29. I now head off for OST lecture. Until Thursday morning I will review lecture notes, these notes, and BRAINWAVES 9.

A diary adds another dimension to the writer's existence. No matter what kind of glances the writer may receive, no matter what types of opinions exist in the heads of his townspeople, the writer of the diary is the hero of the story; the hero in the sense of being the main character.

This does not imply that the world, the entire universe, revolves around the writer of the diary; but metaphysically and philosophically, solipsism cannot be refuted.

THE SELF IS THE ONLY THING THAT EXISTS OR CAN BE PROVED TO EXIST.

I leave for the campus shortly. As I reached for the small dictionary of misunderstood words, I felt what it means to be scholarly, to be a scholar; and as I wrote "to be a scholar", I realized that my human organism is feeding into semantically harmful Verbalizations and thought patterns. The verb "to be", the "is" of identity.

Equating the organism-as-a-whole to scholar or mathematician or computer programmer leads to misevaluation. It is harmful to think "he is a mechanic" or "he is a store clerk" or "she is Mexican" or even "I am a student".

What is the problem with these statements? They fail to recognize the silent, submicroscopic level of existence; dumbing effect. Time for a cigarette organism. It likes to smoke.

3.20 17:00 hrs major change in plans. Chapter 30 has been added to the unit, therefore the exam has been postponed until after Thanksgiving — TUES 30th November. This means I will have to revise my study sheet to make room for "Sources of the Magnetic Field", which will include

① The BIOT-SAVART LAW $\quad dB = k_m \dfrac{I\, d\vec{s} \times \hat{r}}{r^2}$

where k_m is a constant

and $k_m = 10^{-7} \dfrac{T \cdot m}{A}$ This constant is usually written

$$\mu_0 = 4\pi k_m = 4\pi \times 10^{-7}\ Tm/A$$

μ_0 is called the permeability of free space, not to be confused with ε_0 - the permittivity of free space.

Hence the Biot-Savart law can be rewritten as

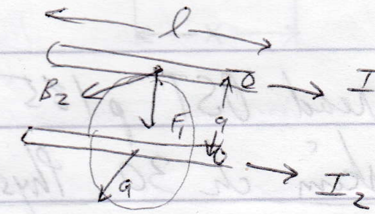
$$dB = \frac{\mu_0}{4\pi} \frac{I\, d\vec{s} \times \hat{r}}{r^2}$$

all this will be covered in the lecture on Thursday 11/18.

$$\therefore B = \frac{\mu_0 I}{4\pi} \int \frac{d\vec{s} \times \hat{r}}{r^2}$$

② Magnetic Force between 2 parallel conductors

$$\frac{F_1}{l} = \frac{\mu_0 I_1 I_2}{2\pi a}$$



③ Ampere's Law $\quad \oint \vec{B}\, d\vec{s} = \mu_0 I$

④ Magnetic Field of a Solenoid $\quad B = \mu_0 \dfrac{N}{l} I = \mu_0 n I$

⑤ Magnetic Flux $\quad \Phi_B = \int \vec{B} \cdot d\vec{A} \Rightarrow BA\cos\theta$

⑥ Guass's Law in Magnetism $\quad \oint \vec{B} \cdot d\vec{A} = \emptyset$

320 17:30 hrs Because ch 30 seems to be rather complicated, involving integration, I may wait until the weekend, until after the lecture, before getting too engrossed in it. I will simply read as much of the Operating System text book as I can today and tomorrow. I will devote much of the study sheet to ch 30 examples. Likewise, over the break, I will focus on the new material. A taste of what is forthcoming:

$$d\vec{s} \times \vec{r} = \hat{k}\,|d\vec{s} \times \vec{r}| = \hat{k}\,(dx \sin\theta)$$

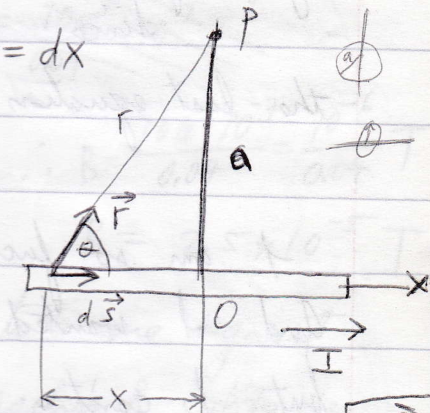
$$\therefore\ d\vec{B} = \hat{k}\, dB \quad \text{with} \quad dB = \frac{\mu_0}{4\pi}\, I\, \frac{dx \sin\theta}{r^2}$$

COGITATION #026

In order to integrate this expression, we must relate the variables θ, x, and r.

$|d\vec{s}| = dx$

We can express x and r in terms of θ.



$\sin\theta = \frac{a}{r}$ (simple enough!)

$$\therefore\ r = \frac{a}{\sin\theta} = a \csc\theta$$

$$\tan\theta = \frac{a}{-x} = -a/x$$

$$\therefore\ x = -\frac{a}{\tan\theta} = -a \cot\theta$$

MAGNETIC FIELD SURROUNDING A THIN, STRAIGHT CONDUCTOR

and $dx = a \csc^2\theta \, d\theta$

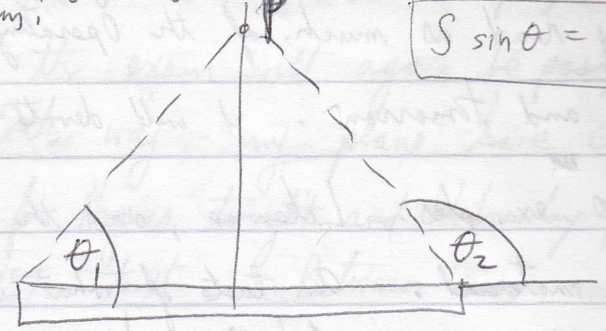
substitute r and dx into $dB = \frac{\mu_0 I}{4\pi} \frac{dx \sin\theta}{r^2}$

yields $dB = \frac{\mu_0 I}{4\pi} \frac{a \csc^2\theta \, d\theta \sin\theta}{a^2 \csc^2\theta} = \frac{\mu_0 I}{4\pi a} \sin\theta \, d\theta$

Now the expression has been reduced to one variable, θ.

We can now obtain the total field at P by integrating over all elements subtending angles ranging from θ_1 to θ_2 as defined in the diagram:

$\boxed{\int \sin\theta = -\cos\theta}$



$$B = \frac{\mu_0 I}{4\pi a}\int_{\theta_1}^{\theta_2} \sin\theta \, d\theta$$

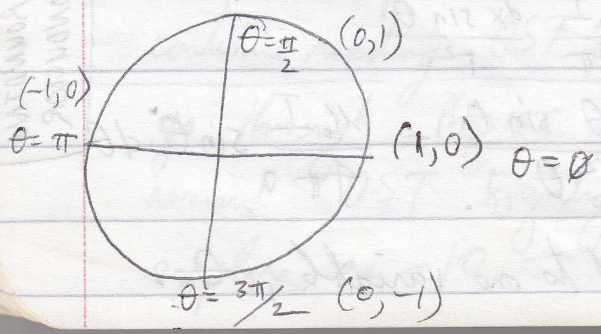
$$\boxed{B = \frac{\mu_0 I}{4\pi a}\left(\cos\theta_1 - \cos\theta_2\right)}$$

Consider the case of an infinitely long straight wire. In this case, $\theta_1 = 0$ and $\theta_2 = \pi$, ~~for~~ segments ranging from $x = -\infty$ to $x = +\infty$.

Since $(\cos\theta_1 - \cos\theta_2) = (\cos 0 - \cos\pi) = 2$

the last equation becomes $\boxed{B = \frac{\mu_0 I}{2\pi a}}$

I am so fucking stimulated. That was a cogitation! And I wanted to let ch 30 alone until the weekend, but I can't. My brain is so stimulated that learning has become an end in itself — not a means to an end (security), but in and of itself an activity that stimulates my cerebral organ as much as SEX. (same source of energy)



$\cos 0 = 1$

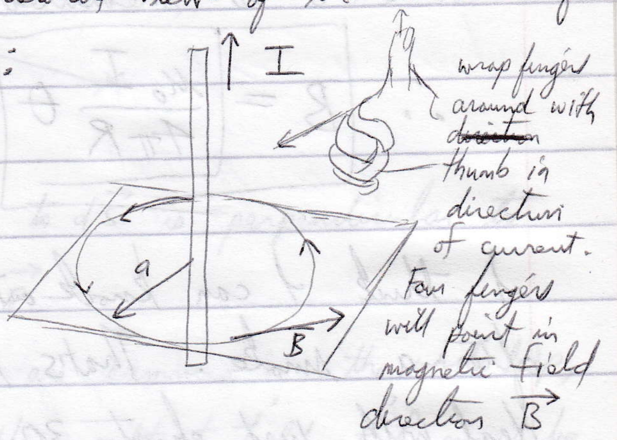
$\cos\pi = \cos 180° = -1$

$\cos 0 - \cos\pi = 1 - (-1) = 2$

and the mess is simplified.

I was going to wait for the lecture. I cannot explain what is happening to me. I guess I have all night to read the OST text. I had better take advantage of the SPIRIT while it FLOWS through me!

COGITATION #027: 3 dimensional view of the direction of B for a long, straight wire:



4 cm from wire carrying 5A yields magnetic field:

$$4\,cm\ \frac{1\,m}{100\,cm} = 0.04\,m$$

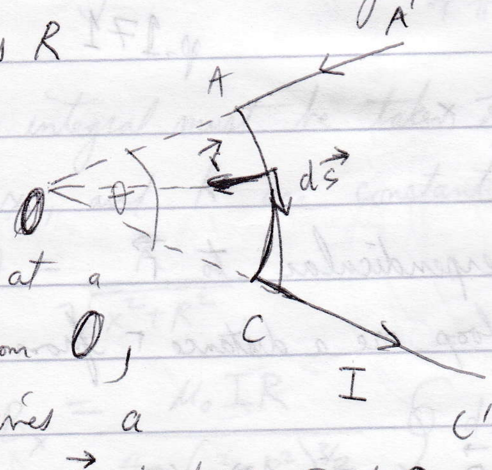
$$B = \frac{\mu_0 I}{\cancel{2}\pi a} = \frac{\mu_0 I}{2\pi a} = \frac{4\pi \times 10^{-7}\,Tm}{2\pi(0.04\,m)}\frac{5A}{A} = \cancel{\frac{10\pi}{0.04}\times 10^{-7}\,T}$$

$$\cancel{10\pi \approx 31.4 \Rightarrow \frac{10\pi}{0.04} = 4\overline{)3140}}\quad \frac{4\pi}{2\pi} \to 2 \therefore B = \frac{10 \cdot 10^{-7}}{0.04} = \frac{10^{-6}}{0.04}\,T$$

$$B = 2.5 \times 10^{-5}\,T$$

COGITATION #028: Magnetic Field due to a wire segment

arc radius R



arc radius R subtends an angle θ

MAGNETIC FIELD at O due to AA' and CC' is ZERO, because $d\vec{s}$ is parallel to $\vec{r}$ along these paths so that $d\vec{s} \times \vec{r} = 0$.

each element along AC is at a distance R from O, and each gives a contribution $d\vec{B}$ directed in ⊗ at O.

at every point on the path AS, $d\vec{s} \perp \vec{r} \therefore |d\vec{s} \times \vec{r}| = ds$

$$\therefore dB = \frac{\mu_0 I}{4\pi}\frac{ds}{R^2}$$

Since R and I are constants, we can easily integrate this expression: $dB = \frac{\mu_0 I}{4\pi} \frac{ds}{R^2}$

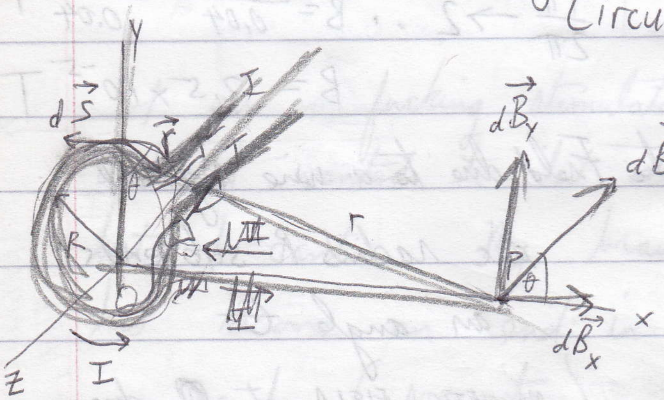
$B = \frac{\mu_0 I}{4\pi R^2} \int ds = \frac{\mu_0 I}{4\pi R^2} s$ note that $s = R\theta$,

where θ is measured in radians.

$$\therefore \boxed{B = \boxed{\frac{\mu_0 I}{4\pi R}} \theta}$$

I think I can knock out the last example of 30.1 after a smoke. That's right. Cognitations #26 to #29 deal with just chapter 30, section 1 of 6, the Biot-Savart Law.

COGNITATION #029: Magnetic Field on the Axis of a Circular Current Loop



I will redraw on p.171

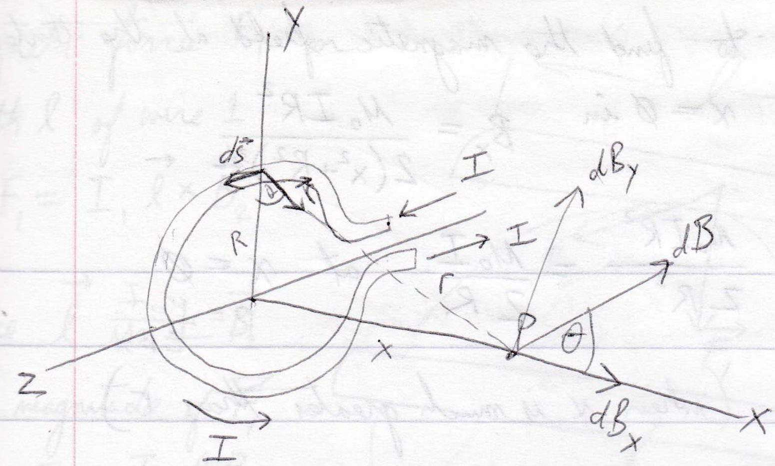
any element $d\vec{s}$ is perpendicular to $\vec{r}$

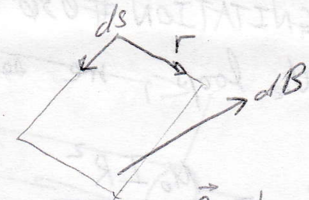
all elements around the loop are a distance r from P.

where $r^2 = x^2 + R^2$

hence, the magnitude of $d\vec{B}$ due to $d\vec{s}$ is

$$dB = \frac{\mu_0 I}{4\pi} \frac{|d\vec{s} \times \hat{r}|}{r^2} = \frac{\mu_0 I}{4\pi} \frac{ds}{(x^2 + R^2)}$$





$d\vec{B}_y \perp$ x-axis

$dB_x \perp$ y-axis

$d\vec{s} \perp \vec{r}$ and $d\vec{B}$ due to $d\vec{s}$ is perpendicular to the plane formed by $d\vec{s}$ and $\vec{r}$

When the components $\perp$ x-axis are summed over the whole loop, the result is zero. Therefore, the resultant field at P must be along the x-axis and can be found by integrating the components $dB_x = dB\cos\theta$, where this expression is obtained from resolving the vector $d\vec{B}$ into its components.

That is, $\vec{B} = B_x\,\vec{i}$, where

$$B_x = \oint dB\cos\theta = \frac{\mu_0 I}{4\pi}\oint \frac{ds\cos\theta}{x^2+R^2}$$

and the integral must be taken over the entire loop.

θ, x, and R are constants for all elements in the loop.

$$\cos\theta = \frac{R}{\sqrt{x^2+R^2}}$$

$$\therefore\ B_x = \frac{\mu_0 I R}{4\pi(x^2+R^2)^{3/2}}\oint ds = \frac{\mu_0 I R^2}{2(x^2+R^2)^{3/2}}$$

where we have used the fact that $\oint ds = 2\pi R$ the circumference of the loop.

COGNITATION #030: to find the magnetic field at the center of the loop, we set $x = 0$ in $B_x = \dfrac{\mu_0 I R^2}{2(x^2+R^2)^{3/2}}$

$$B_{x=0} = \frac{\mu_0 I R^2}{2(0+R^2)^{3/2}} = \frac{\mu_0 I R^2}{2R^3} = \frac{\mu_0 I}{2R} \quad \text{at } x = 0$$

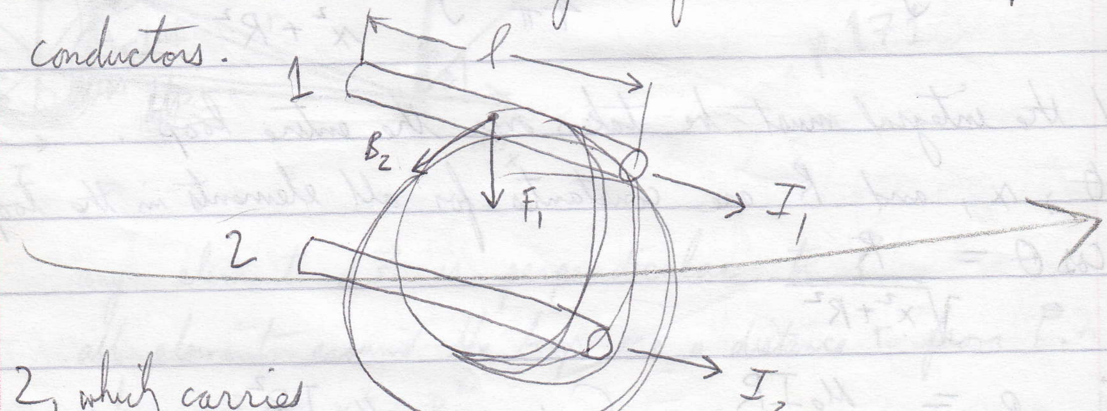
$$R = \frac{\mu_0 I}{2B_x}$$

when $x \gg R$ (when x is much greater than r)

$$B \approx \frac{\mu_0 I R^2}{2x^3}$$

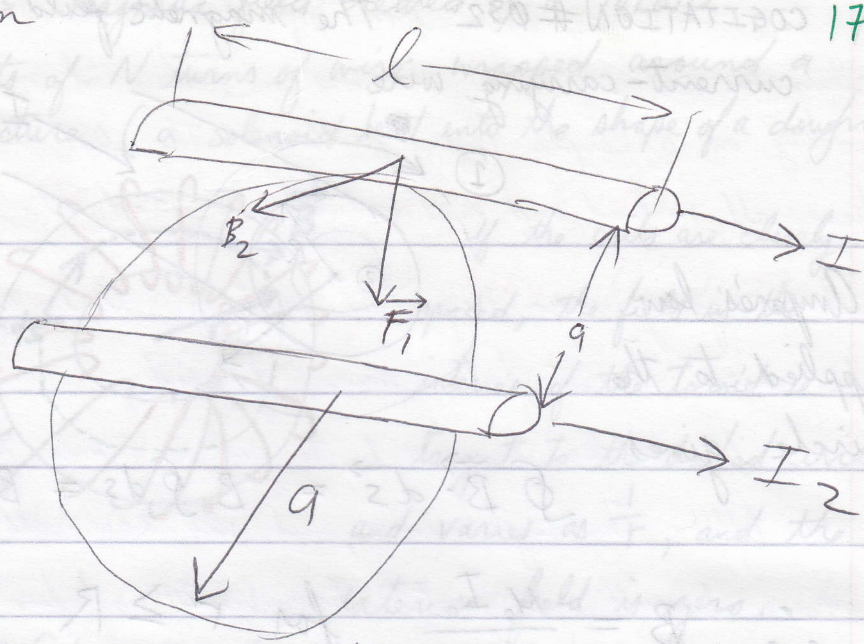
WOW. Should I keep going? Why not. I can read the OST text later and tomorrow night. Besides, going over the material prior to the lecture will cause the lecture to really SINK IN. Also, both OST and JAVA, although in my majors, take a back seat to Physics.

COGITATION #031: The magnetic force between two parallel conductors.



wire 2, which carries I_2, creates $\vec{B}_2$ at the position of wire 1

magnetic force F_1 on length l of wire 1 is $F_1 = I_1 \vec{l} \times \vec{B}_2$



since $\vec{l}$ is $\perp$ $\vec{B}_2$ the magnitude of $\vec{F}_1$ is $F_1 = I_1 l B_2$

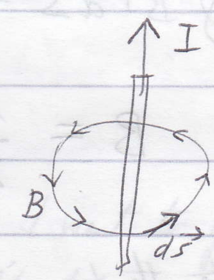
the field created by wire 2 is given in cogitation #Ø26 p.168

$$B_2 = \frac{\mu_0 I_2}{2\pi a}$$

hence, $F_1 = I_1 l B_2 = I_1 l \left(\frac{\mu_0 I_2}{2\pi a}\right) = \frac{\mu_0 I_1 I_2}{2\pi a} l$

We can rewrite this in terms of Force per unit length:

$$\frac{F_1}{l} = \frac{\mu_0 I_1 I_2}{2\pi a}$$

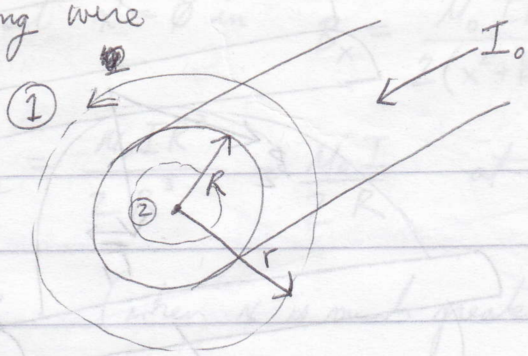


COGITATION #Ø31: Ampere's Law

$$\oint \vec{B} \cdot d\vec{s} = B \oint ds = \frac{\mu_0 I}{2\pi r}(2\pi r) = \mu_0 I$$

$$\oint \vec{B} \, d\vec{s} = \mu_0 I$$

COGITATION #032 The magnetic feild created by a long, current-carrying wire



Ampere's law applied to the circle gives

$$\oint \vec{B}\cdot d\vec{s} = B\oint ds = B(2\pi r) = \mu_0 I_0$$

$$\therefore \quad B = \frac{\mu_0 I_0}{2\pi r} \quad \text{for } r \geq R \quad \text{region } 1$$

this is identical to the meaning of the equation developed in cognition #26.

In region 2, where $r < R$, $I > I_0$.

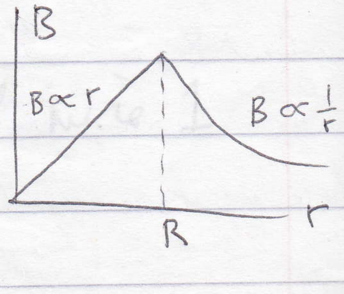
and $\dfrac{I}{I_0} = \dfrac{\pi r^2}{\pi R^2} \Longrightarrow I = \dfrac{r^2}{R^2} I_0$

$$\oint \vec{B}\cdot d\vec{s} = B(2\pi r) = \mu_0 I = \mu_0\left(\frac{r^2}{R^2} I_0\right)$$

$$\therefore \quad B = \frac{\mu_0 I_0 r}{2\pi R^2} \quad \text{for } r < R$$

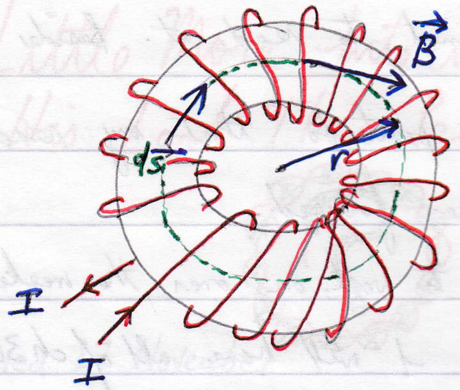
Note that, inside the wire, $B \to \emptyset$ as $r \to \emptyset$

The field is proportional to r inside the wire and varies as $\frac{1}{r}$ outside the wire.



COGNITATION # Ø33 Magnetic field created by a Toroid.

a toroid consists of N turns of wire wrapped around a ring-shaped structure (a solenoid bent into the shape of a doughnut)



If the coils are closely spaced, the field in the interior of the toroid is tangent to the dashed circle and varies as $\frac{1}{r}$, and the exterior field is zero.

inside the toroid:

$$\oint \vec{B} \cdot d\vec{s} = B \oint ds = B(2\pi r) = \mu_0 N I$$

$$B = \frac{\mu_0 N I}{2\pi r}$$

COGITATION #Ø34: Magnetic field created by an infinite-current sheet

infinite sheet in YZ plane carries surface current density J_s.

$$\oint \vec{B} \cdot d\vec{s} = \mu_0 I = \mu_0 J_s l$$

$$2B\vec{l} = \mu_0 J_s \vec{l}$$

$$B = \mu_0 \frac{J_s}{2}$$

22:00 hrs I think that this will do it for now. I want to get some reading of the OST text done. Still left to cover:

Magnetic Force on a current segment $F = \frac{\mu_0 I_1 I_2}{2\pi} \ln\left(1 + \frac{b}{a}\right)$]

Magnetic Force of a solenoid: $B = \mu_0 \frac{N}{l} I = \mu_0 n I$

Magnetic Flux $\Phi_B = \int \vec{B} \cdot d\vec{A} = BA\cos\theta$

Magnetic Flux through a rectangular loop $\Phi_B = \frac{\mu_0 I b}{2\pi} \ln\left(\frac{a+c}{c}\right)$

Magnetic Flux through any closed surface $\oint \vec{B} \cdot d\vec{A} = \varnothing$

321 04:20 hrs – another sleepless night; but nothing like the night I got stuck in Harlem when Tom Tully and I missed the last bus out of Hell and got caught in the cold downpour of October 14-15 1995. That was my day to die, and here I am. Overtime. Bonus years.

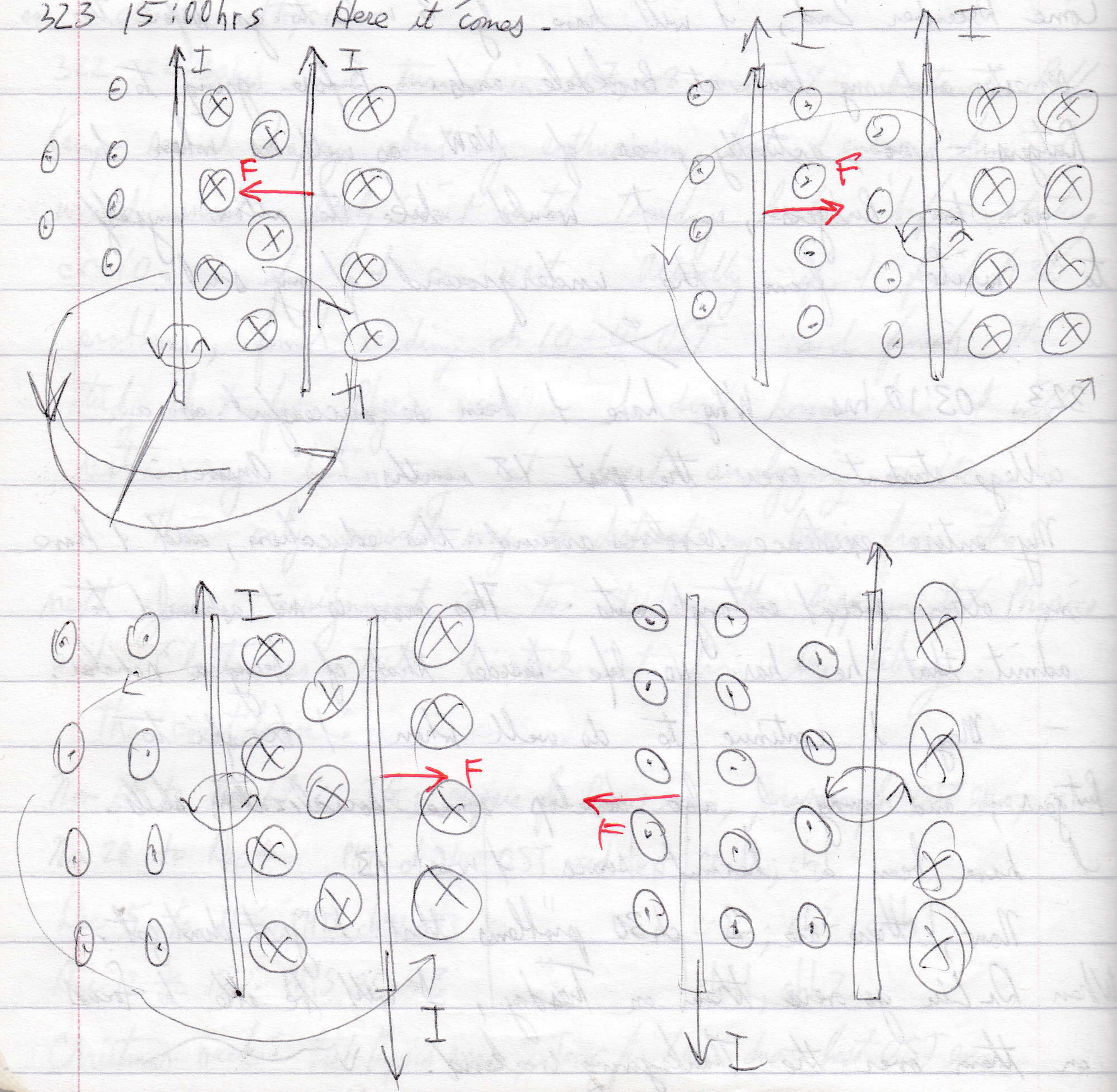
So much flows through this insomniacal phantasmagoria, from thoughts of what the superintendents of the local parks think of a maintenance worker fired for being arrested after being chased down by police making the National Deans list and being inducted into an International Honors Society and majoring in Computer Science as a math minor to visions of that night in Harlem to visions of the sweat lodge ceremonies, my kneeling in thankfulness in the Tark House, invasion of the crack heads, and just general chaos, madness, and dreams.

My story is not a pleasant one; it is neither sweet or harmonious, as invented stories are. I am a man who has long since ceased deceiving himself. No more false modesty either. An English professor at Brookdale had told me that I was by far the most well read student he had ever taught, and that I had a great command over language and ideas. Most professors, whether in computer science, calculus, physics, philosophy, psychology, or anthropology have been "impressed". I have a presence, a boldness of intellect. And yet, I cannot sleep.

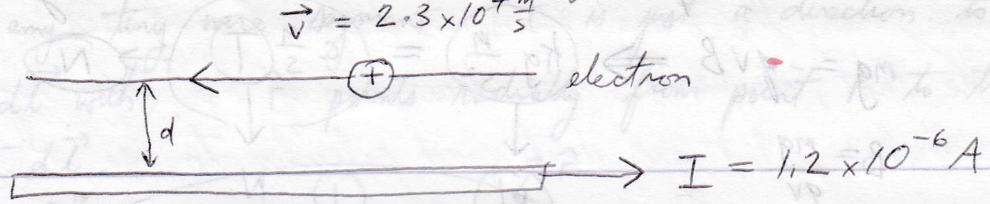
323 @4:00hrs I will be sleeping in tomorrow for a good part of the day. I am giving myself a break. All I expect to accomplish before Monday night is to finish reading ch 10 and 11 of OST text and create study sheet (as well as some browsing of supplementary physics books). I will not be knocking myself out like I have been.

Come Wednesday night (24 NOV), I will be on Physics, OST, and Java cr-10.

323 15:00hrs Here it comes.



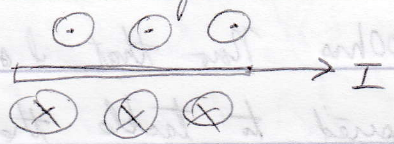
I solved problem #7 ch 30 on my own!



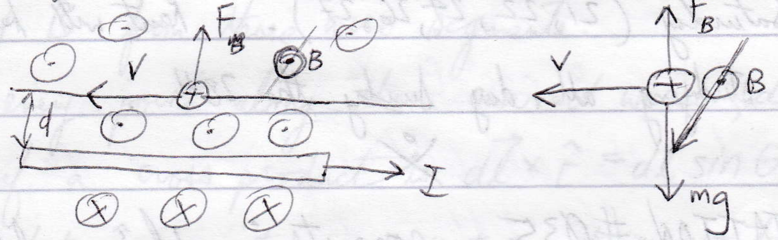
find d.

known: electron mass $m = 1.67 \times 10^{-27}$ kg
electron charge $q = 1.6 \times 10^{-19}$ C
given electron velocity $= 2.3 \times 10^4$ m/s left bound

solution: A force has to keep the mass of the electron a distance d from the wire



The field B up by the moving electron is moving out of the page, hence the Magnetic Force is in the upward direction, which is balancing out the weight of the electron!



How to relate $B = \frac{\mu_0 I}{2\pi a}$ for wire (where a is distance d) to $F_B = qvB$ for the charge? eureka: mg is a force

$$mg = qvB \Rightarrow B = \frac{mg}{qv}$$

$$B = \frac{\mu_0 I}{2\pi a} \Rightarrow a = d = \frac{\mu_0 I q v}{2\pi mg} \text{ !!! } \ldots = 5.39 \times 10^{-2} \text{ m}$$

The units of measurement also tell a story.

$$mg = qvB \Longrightarrow \left(kg\,\frac{m}{s^2}\right) = \left(c\,\frac{m}{s}\,T\right) \rightarrow N$$

$$kg\,\frac{m}{s^2} \downarrow N \qquad T \downarrow \frac{N}{c\,\frac{m}{s}}$$

$$B = \frac{mg}{qv}$$

$$B = \frac{\mu_0 I}{2\pi a}$$

$$a = \frac{\mu_0 I}{2\pi B} = \frac{\mu_0 I q v}{2\pi mg} \Longrightarrow \frac{Tm\;A\;c\,\frac{m}{s}}{A\;kg\,\frac{m}{s^2}} \rightarrow \frac{N\;m\cancel{kg}\,\frac{m}{s}}{\frac{m}{s}\cancel{c}\,A\,N} = m$$

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323 16:00hrs Now that I solved that problem, I am motivated and inspired to tackle the other one I was stuck on. If I can solve it, I will start working on my study sheet. Later this evening I will continue reading the OST text. I will be working with Dad Sunday, Monday, Wednesday, Friday, and Saturday (21, 22, 24, 26, 27). Rent will be paid. I will be studying all day Sunday the 28th.

COGITATION #Ø35 concepts: dl: a little peice of wire

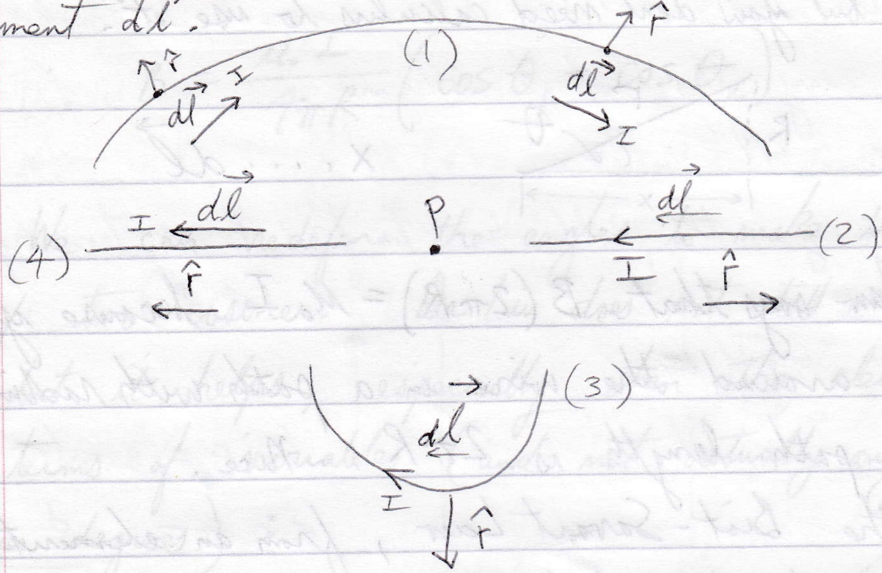
dB: a little piece of magnetic field cased by the current going through dl. r: distance from dl to point P

$\hat{r}$: direction of a unit vector which points from P to dl.

I: the current which flows through the wire.

$$dB = \frac{\mu_0}{4\pi}\,\frac{I\,\vec{dl} \times \hat{r}}{r^2}$$

$\vec{dl}$ is a vector which points in the direction of the current along any tiny wire segment. $\hat{r}$ is just a direction to cross $\vec{dl}$ with. $\hat{r}$ points radially from point P to the segment $\vec{dl}$.



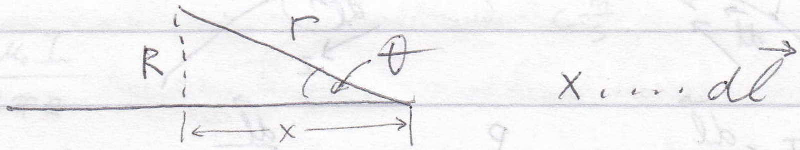
No reason to go screaming to the hills. Along the straight segments, (2) and (4), $\hat{r}$ and $\vec{dl}$ point along the same line, so $\vec{dl} \times \hat{r} = \emptyset$, and there is no contribution to the magnetic field B from those wire segments.

And at every point along the curved wires, $\vec{dl} \perp \hat{r}$! The magnitude of a cross product is $\vec{dl} \times \hat{r} = dl \sin\theta$. (Keep in mind that $\hat{r}$ is just a unit vector. Its magnitude is 1.) $\vec{dl} \perp \hat{r}$ means $\theta = 90°$ everywhere on the circular wire! Jump for joy for $\sin 90° = 1$! The cross product reduces to dl.

$$dB = \frac{\mu_0 I \, dl}{4\pi r^2}$$

The problem I am stuck on is not so straight forward.

COGITATION #036 : The Biot-Savart Law and Ampere's Law are the same laws in different disguises! Note that, as usual, the derivation of the law requires calculus, but you don't need calculus to use it.



Ampere's law says that $B(2\pi R) = \mu_0 I$ because you can circle around the wire in a path with radius R, and the path length is $2\pi R$. Nice.

Using the Biot-Savart Law, from an element of length dx at slant distance r, $dB = \frac{\mu_0}{4\pi} \frac{I\, dx \sin\theta}{r^2}$

$|d\vec{s}| = dx$

see $\cos_{26}$ p. 167. ① $\sin\theta = \frac{R}{r} \Rightarrow r = \frac{R}{\sin\theta} = R\csc\theta$

② $\tan\theta = \frac{R}{-x} \Rightarrow x = \frac{-R}{\tan\theta} = -R\cot\theta$

[see page 3 for step 3]

③ $dx = R\csc^2\theta\, d\theta$

④ Make the substitutions for r and dx, and then the only variable left is θ.

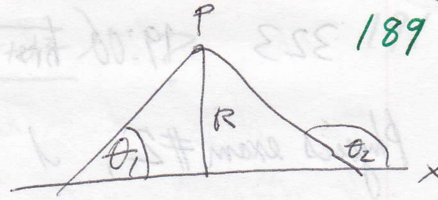
$$dB = \frac{\mu_0}{4\pi} \frac{I\,(R\csc^2\theta\, d\theta)\sin\theta}{(R^2\csc^2\theta)}$$

$$dB = \frac{\mu_0 I}{4\pi} \frac{\sin\theta\, d\theta}{R}$$

We can now obtain the total magnetic field B at P by integrating

see p. 168

$$B = \frac{\mu_0 I}{4\pi R}\int_{\theta_1}^{\theta_2} \sin\theta \, d\theta$$

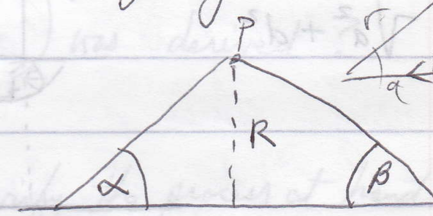


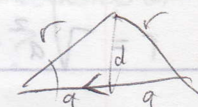
$$\int \sin\theta \, d\theta = -\cos\theta$$

$$\therefore \; B = \frac{\mu_0 I}{4\pi R}\left(\cos\theta_1 - \cos\theta_2\right)$$

We can redefine the angles to make this the sum of two cosines. Dr Lin does not tell us about this, but it helps, especially when the elements are in terms of variables (and not actually angles in radians or degrees):

$$B = \frac{\mu_0 I}{4\pi R}\left(\cos\alpha + \cos\beta\right)$$





I will now try to apply these insights to problem #13 of ch 30. There is one thing that is certain. Logbook #59 is packed with Physics II Cogitations. I suspect that logbooks 60 to 62 will be packed with Multivariable Calculus and Linear Algebra cogitations.

On December 26th or thereabouts, in Logbook #60, I will be focusing cogitations on Calculus II problems (from 1995 notes) so as to review for Calculus III 2000 (multivariable Calculus).

$$\cot\theta = \frac{\cos\theta}{\sin\theta} = \frac{1}{\tan\theta} \; ; \quad \csc\theta = \frac{1}{\sin\theta} \; ; \quad \sec\theta = \frac{1}{\cos\theta}$$

How to arrive at $\dfrac{\mu_0 I \left(a^2+d^2-d\sqrt{a^2+d^2}\right)}{2\pi\, ad\sqrt{a^2+d^2}}$?

323 23:00hrs I suppose I could work backwards like a detective.

This is my own off the wall notation:

$$\left.\begin{array}{l} X \leftarrow \mu_0 I \\ M \leftarrow 2\pi \end{array}\right\} \frac{X\left(a^2+d^2-d\sqrt{a^2+d^2}\right)}{M\, ad\sqrt{a^2+d^2}}$$

Fuck it. not much simpler

break it down to subtraction:

$$\frac{(\mu_0 I)(a^2+d^2)}{2\pi\, ad\sqrt{a^2+d^2}} - \frac{\left(d\sqrt{a^2+d^2}\right)(\mu_0 I)}{2\pi\, ad\sqrt{a^2+d^2}}$$

What did the separate terms look like before the common denominator was derived?

Always use a simple case to clarify the process at hand:

$$\frac{5x}{12} - \frac{3}{61} \Rightarrow \frac{(5x)(61)-(3)(12)}{(12)(61)}$$

$$\frac{a}{c} - \frac{b}{d} = \frac{ad-bc}{cd}$$

here we have $\dfrac{X}{M}\left(\dfrac{a}{c}-\dfrac{b}{d}\right) = \dfrac{X}{M}\left(\dfrac{ad-bc}{cd}\right) = \dfrac{Xad-Xbc}{Mcd}$

what does ad have in common with cd? d not? c

∴ a is numerator, c is denominator.

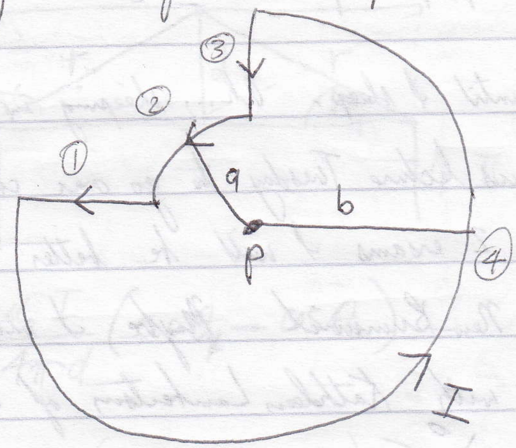
Now, apply this process to our complex instance: remove $\left(\dfrac{\mu_0 I}{2\pi}\right)$

(a^2+d^2) ∴?∴ $ad\sqrt{a^2+d^2} \longrightarrow \dfrac{\sqrt{a^2+d^2}}{d} \to \dfrac{r}{d} \to \csc\theta$!!! $= \dfrac{1}{\sin\theta}$

$d\sqrt{a^2+d^2}$ ∴?∴ $ad\sqrt{a^2+d^2} \longrightarrow a$ ∴ -1 numer, a denominator

~~COGNIT~~ COGITATION #Ø37

Use the Biot Savart Law to derive an expression for the net magnetic field at point P.



$$d\vec{B} = \frac{\mu_0 I}{4\pi} \frac{d\vec{s} \times \hat{r}}{r^2}$$

① $\leftarrow d\vec{s}$ $\quad \cdot P \quad$ $\hat{r} \rightarrow$

angle between $d\vec{s}$ and $\hat{r}$ is $180°$

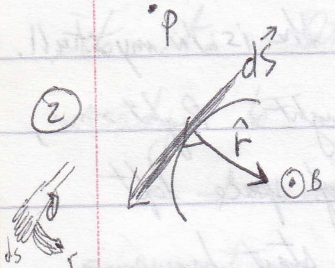
$\sin 180° = \emptyset$, $\therefore B_1 = \emptyset$

③ $d\vec{s} \downarrow \quad \hat{r} \downarrow$

angle between $d\vec{s}$ and $\hat{r}$ is $0°$

$\sin \emptyset = \emptyset \quad \therefore B_3 = \emptyset$

②



angle between $d\vec{s}$ and $\hat{r}$ is $90°$

$\sin 90° = 1 \quad B_2$ exists (out of page)

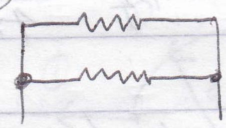
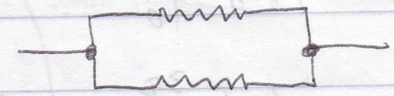
$$d\vec{B}_2 = \frac{\mu_0 I}{4\pi a^2} \int d\vec{s} = \frac{\mu_0 I s}{4\pi a^2}\Big|_{?}^{?} = \frac{\mu_0 I r \theta}{4\pi r^2}$$

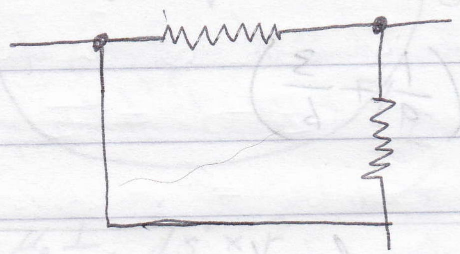
arc $s = r\theta$ where, here, $a \leftarrow r$

$$\therefore B_2 = \frac{\mu_0 I a \theta}{4\pi a^2} = \frac{\mu_0 I \theta}{4\pi a}\Big|_{\theta=\emptyset}^{\theta=\pi/2}$$

$$B_2 = \frac{\mu_0 I \frac{\pi}{2}}{4\pi a} - \emptyset = \frac{\mu_0 I}{8a}$$

COGITATION #Ø38: review resistors
DC CIRCUITS

There are several ways to draw resistors in parallel: ①  or ② 

or even ③ 

In each, the resistors are connected directly accross the battery terminals.

figure ② is the most clear to me. I see where the circuit "splits". 

figure ① "splits" the circuit as such: 

and figure ③ splits the circuit as: 

When it splits, $I = I_1 + I_2$ and this is parallel.

$I = \frac{\mathcal{E}}{R}$ $\therefore$ $\frac{\mathcal{E}}{R} = \frac{\mathcal{E}}{R_1} + \frac{\mathcal{E}}{R_2} + \frac{\mathcal{E}}{R_3}$

No memorization is required.

In parallel, where $V = V_1 = V_2 = V_3$, and $V = IR$

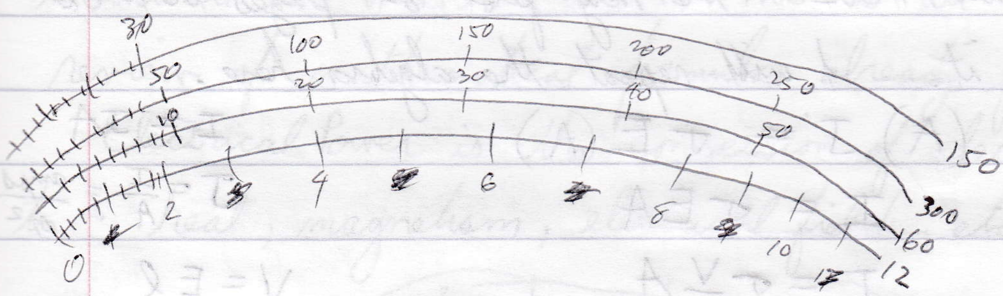
$I_1 = \frac{\mathcal{E}}{R_1}$ and $R_1 = \frac{\mathcal{E}}{I_1}$

Before I get into a full scale review of DC circuits, I will solidify my grasp of Magnetic Fields

324 18:20hrs COGITATION #039: UNITS of measurement 199

US conventional units are fucked up. What the hell is a dyne? Force is measured in dynes. Fuck that. I will stick with SI units. Force is measured in Newtons. I will return all text books to library Monday evening, and I will try to find an electronics book that uses the SI system. No more pounds, dynes, maxwells, or unit poles. The SI system is here to stay. Goodbye "US conventional"!

COGITATION #040: reading analog scale



~~12~~ range: 12 AC/DC

$$\frac{\text{first marked number}}{\text{count}} = \text{value each line}$$

$\frac{2}{10} = 0,2$ each line

range: 60 AC/DC $\frac{10}{10} = 1$ each line

range: 300 AC/DC $\frac{50}{10} = 5$ each line

range: 150 AC/DC $\frac{30}{15} = 2$ each line

COGITATION #Ø41: In Electronics books, Ohm's Law is usually expressed as: Given any two of the variables (V, I, R), Ohm's law solves for the third:

Voltage = current * resistance

$$R = \frac{V}{I}$$

In Dr. Xiaxuang Liu's Physics class, we start we a very different definition of Ohm's Law:

$$J = \sigma E$$

current density = conductivity * electric field.

In cogitation #001 - the very first on pages 63 to 66 I go over it. I will repeat the algebra here.

$$(A)\, J = \sigma E\, (A)$$

$$I = \sigma E A$$

$$I = \sigma \frac{V}{l} A$$

$$I = JA$$

$$J = \frac{I}{A} = \frac{\text{amps}}{m^2}$$

$$V = El$$

$$E = \frac{V}{l}$$

rewritten as $I = \dfrac{V}{\dfrac{l}{\sigma A}} = \dfrac{V}{R}$

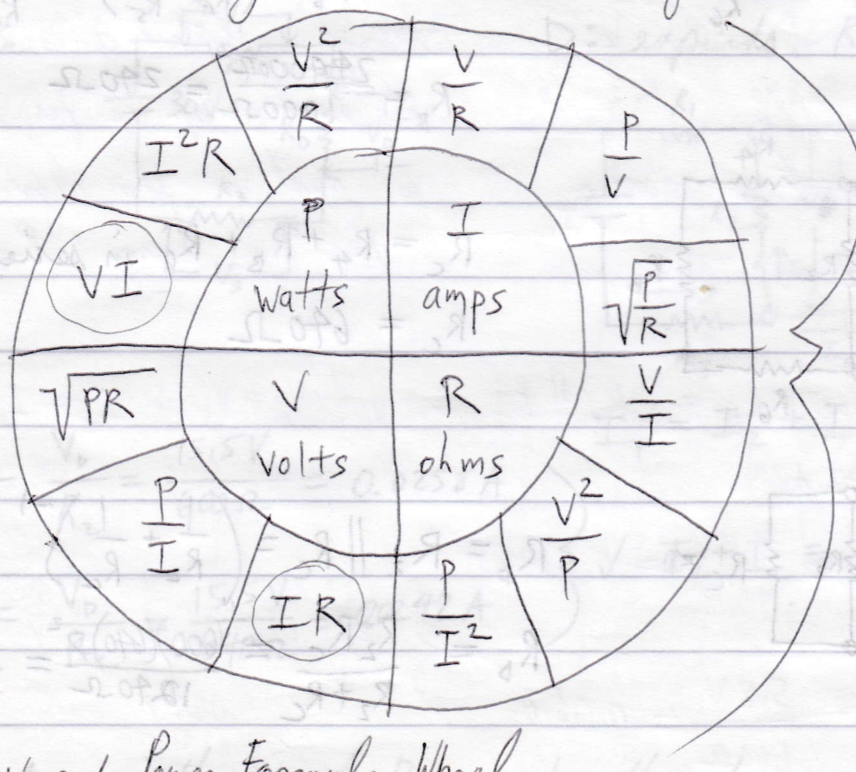
$\therefore R = \dfrac{l}{\sigma A}$; $\sigma = \dfrac{1}{\rho}$ $\therefore R = \rho \dfrac{l}{A} = \dfrac{V}{I}$

conductivity σ is the inverse of resistivity ρ - Note that Resistance R is the opposition to the flow of electric current I. Resistance does not slow down the current. Resistance restricts the volume of the current

travelling in the circuit. Larger resistance results in less current, and smaller resistance results in more current. Resistance describes "electrical load". Work performed by electricity takes place in the load. When current flows through a load, it causes a difference in potential (voltage), also called voltage drop (potential difference V), accross the resistance.

The voltage drop multiplied by the current through the load is POWER. Power is work performed. Power (work performed = voltage time current = VI) is measured in watts (W). This is all a verbal review of mathematical formulas already familiar.

Electrical Power is the conversion of election flow to: heat, magnetism, electrical fields, etc...



BASE FORMULAS

$V = IR$

$P = IV$

$= I^2R$

$= V^2/R$

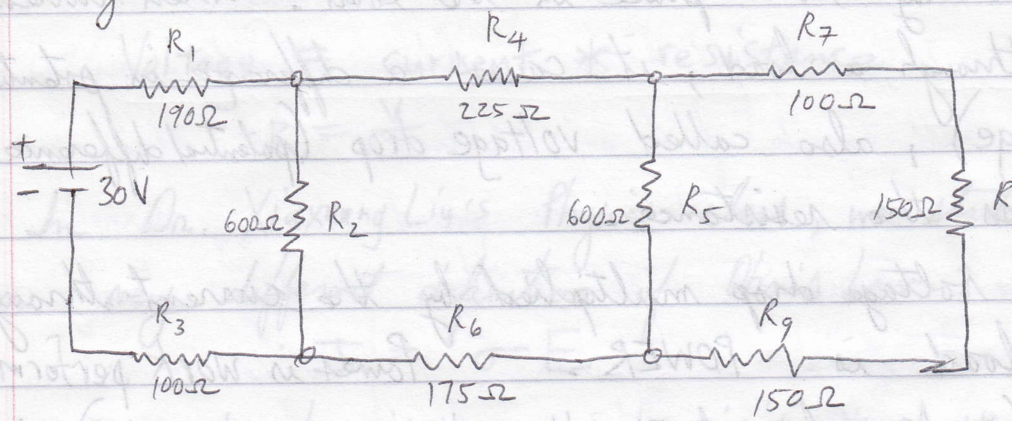
from these, the rest follow using algebra

Ohm's Law and Power Formula Wheel

COGITATION #042: *Series-Parallel Circuit*

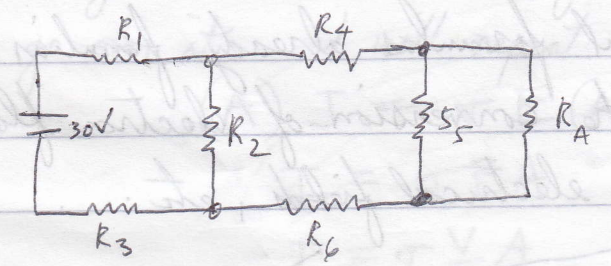
FIRST, FIND TOTAL RESISTANCE

original circuit: [call it A]



$R_A = R_7 + R_8 + R_9$ in series $\quad R_A = 400\,\Omega$

B:

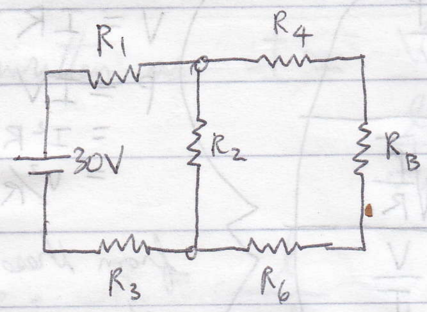


$R_B = R_A \parallel R_5$

$$R_B = \left(\frac{1}{R_A} + \frac{1}{R_5}\right)^{-1} = \frac{R_A R_5}{R_A + R_5}$$

$$R_B = \frac{240000\,\Omega^2}{1000\,\Omega} = 240\,\Omega$$

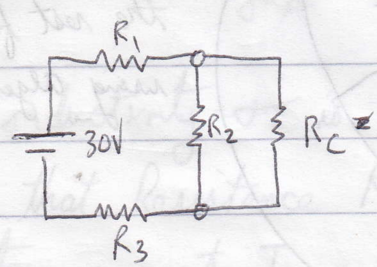
C:



$R_C = R_4 + R_B + R_6$ in series

$R_C = 640\,\Omega$

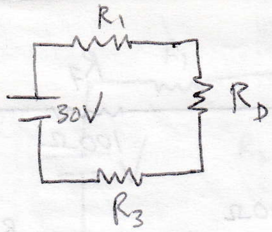
D:



$$R_D = R_2 \parallel R_C = \left(\frac{1}{R_2} + \frac{1}{R_C}\right)^{-1}$$

$$R_D = \frac{R_2 R_C}{R_2 + R_C} = \frac{(600)(640)\,\Omega^2}{1240\,\Omega} = 310\,\Omega$$

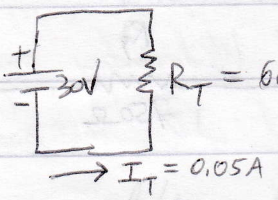
E:



$R_T = R_1 + R_D + R_3$ in series

$R_T = 600\,\Omega$

F:



Now, we can find the current and voltage drops of each resistor in the circuit.

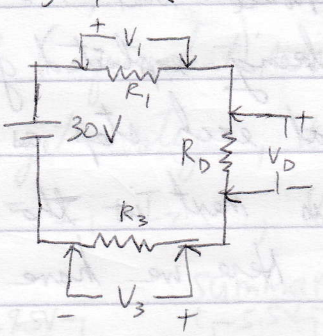
$$I_T = \frac{V}{R_T} = \frac{30V}{600\,\Omega} = 5.0 \times 10^{-2} A = 0.05A = 50mA \quad (\text{use } 0.05A)$$

We can start to expand towards the original circuit now. I share diagram F. Note current I is an afterthought.

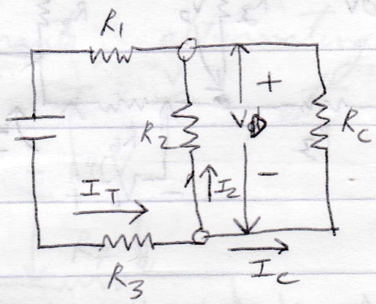
Diagram E shows resistors in series. $V_1 + V_D + V_3 = V_T$; $I_T = I_1 = I_D = I_3$

$$\left.\begin{aligned} V_1 &= R_1 I_T = (190\,\Omega)(0.05A) = 9.5V \\ V_D &= R_D I_T = (310\,\Omega)(0.05A) = 15.5V \\ V_3 &= R_3 I_T = (100\,\Omega)(0.05A) = 5V \end{aligned}\right\} \text{series total } V = 30V \checkmark$$

∴ E:



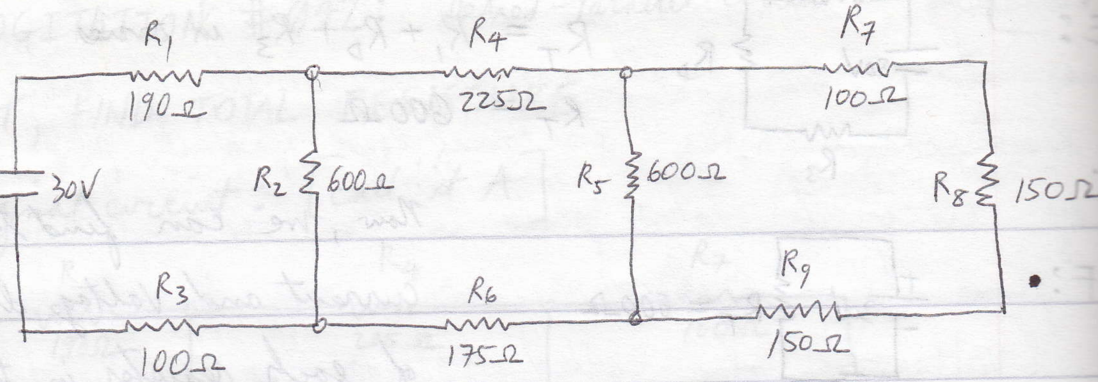
D: expands R_D ($V_D = 15.5V$)



$I_T = I_2 + I_C$ $\quad R_2 \| R_C$

$$\left.\begin{aligned} I_2 &= \frac{V_D}{R_2} = \frac{15.5V}{600\,\Omega} = 0.0258A \\ I_C &= \frac{V_D}{R_C} = \frac{15.5V}{640\,\Omega} = 0.0242A \end{aligned}\right\} \checkmark \; I_2 + I_C = I_T \checkmark$$

next we will expand R_C. I will redraw original first.



original circuit

C: expand R_C (note that $R_C = R_4 + R_B + R_6$ in series)

first compute voltage drops. $V_4 + V_B + V_6 = V_D = 15.5V$

also note that, in series $I_C = I_4 = I_B = I_6 = 0.0242A$

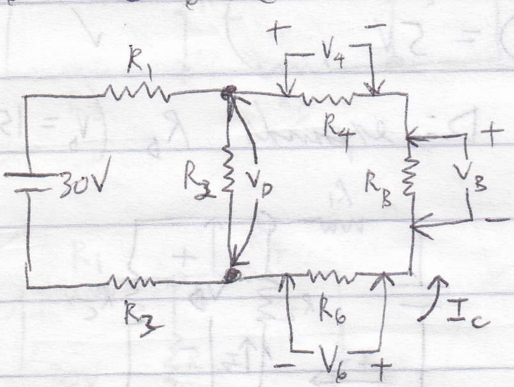
$V_4 = I_C R_4 = (0.0242A)(225\Omega) = 5.45V$

$V_B = I_C R_B = (0.0242A)(240\Omega) = 5.8V$

$V_6 = I_C R_6 = (0.0242A)(175\Omega) = 4.25V$

} V_D ✓

C:



Notice that the notation being exploited gives clues at each step as far as what is next in the algorithm. Here we have R_B.

recall that $R_B = R_A \parallel R_5$: $V_B = V_A = V_5$: $I_C = I_A + I_5$

$I_C = 0.0242A$

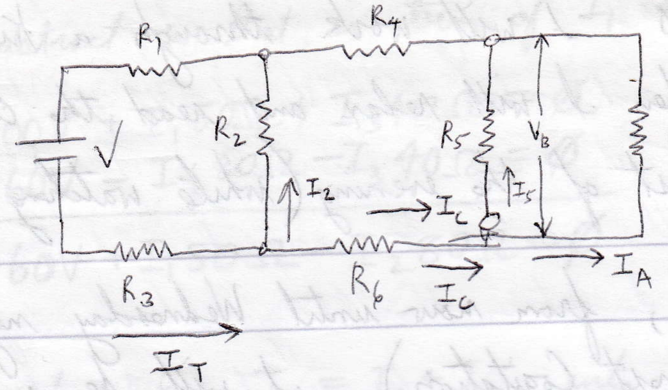
$I_A = \frac{V_B}{R_A} = \frac{5.8V}{400\Omega} = 0.0145A$

$I_5 = \frac{V_B}{R_5} = \frac{5.8V}{600\Omega} = 0.0097A$

} $I_C = I_A + I_5$

$$\begin{array}{r} 0.0097 \\ \underline{0.0145} \\ 0.0242 \end{array}$$

B:



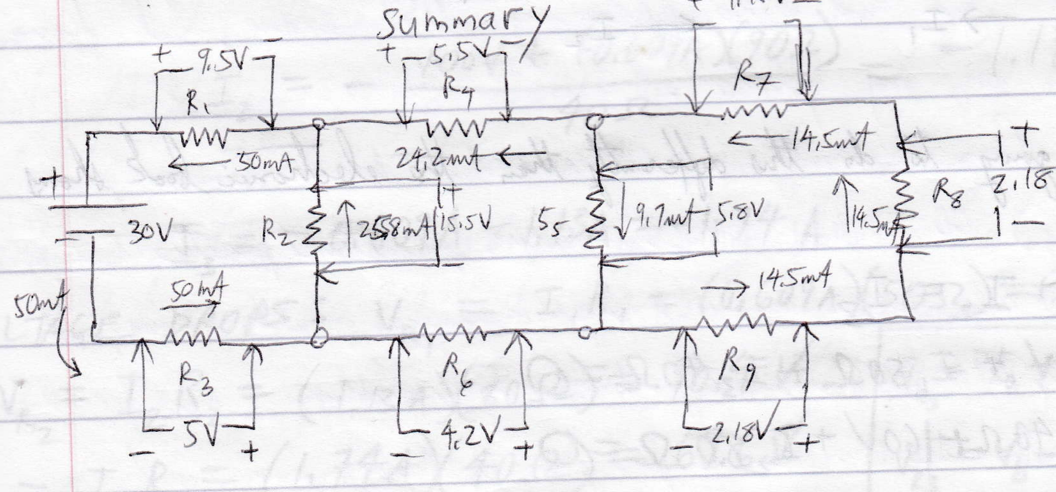
$I_C = I_5 + I_A$

R_A is left. Recall that $R_A = R_7 + R_8 + R_9$ in series therefore I is the same for each, $I_A = 0.0145$ A

$$\left.\begin{aligned} V_7 &= I_A R_7 = (0.0145A)(100\Omega) = 1.45V \\ V_8 &= I_A R_8 = (0.0145A)(150\Omega) = 2.18V \\ V_9 &= I_A R_9 = (0.0145A)(150\Omega) = 2.18V \end{aligned}\right\} V_B = 5.81V \checkmark$$

Obviously this will take about 90 minutes (at least) on the exam. I will remain calm. The pattern is: get total (equivalent) resistance, then get total current, then get voltages, then currents, alternating between $I = I_1 + I_2$, $V = IR$, $I = \frac{V}{R}$, etc.

Summary



324 22:00hrs I will work through a Kirchhoff circuit, and then I will relax and read the OST text book for the rest of the evening (while watching TV after 11PM). Yes, from now until Wednesday night (right after this next Cogitation), I will be reading. If I have time Monday evening, I may even read some of the Java text to prepare for Tuesday's lecture.

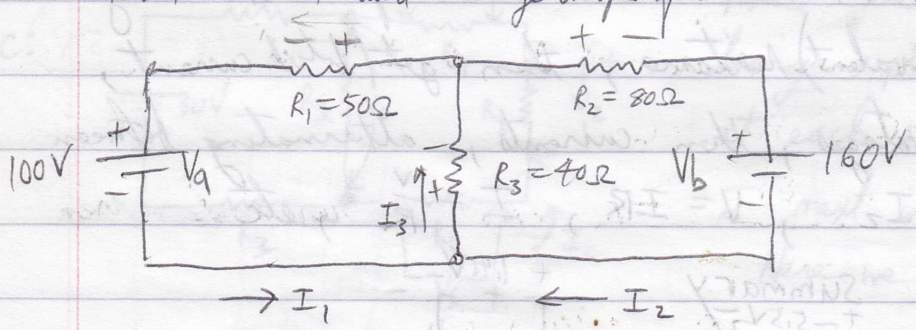
Plan: 20, 21, 22 (Sat-Mon) read OST + Java text

23, 24, 25, 26, 27, 28, 29 (Tues-Mon) prepare for EXAMS, ch-10

After December 1st: PHYSICS and JAVA and a little OST

COGITATION #Ø43: 2 LOOPS, 2 VOLTAGE SOURCES

Find current and voltage drops for each resistor



I am going to do this differently than the electronic book shows.

$I_1 + I_2 = I_3$

$100V + I_1 50\Omega + I_3 40\Omega = 0$

$I_3 40\Omega + 160V + I_2 80\Omega = 0$

substract so that in term of I_1 and I_2

$$100V + I_1 50\Omega + I_3 40\Omega = \emptyset$$
$$-\ \underline{160V - I_2 80\Omega - I_3 40\Omega = \emptyset}$$
$$-60V + I_1 50\Omega - I_2 80\Omega = \emptyset$$

now substitute $I_3 = I_1 + I_2$ into original

$$100V + I_1 50\Omega + (I_1 + I_2) 40\Omega = \emptyset$$
$$100V + I_1 90\Omega + I_2 40\Omega = \emptyset$$
$$-I_2 40\Omega = 100V + I_1 90\Omega$$
$$I_2 = -\left(\frac{100V + I_1 90\Omega}{40\Omega}\right)$$

now I can substitute into the derived equation to solve for I_1

$$-60V + I_1 50\Omega + \frac{80\Omega}{40\Omega}(100V + I_1 90\Omega) = \emptyset$$
$$-60V + I_1 50\Omega + 200V + I_1 180\Omega = \emptyset$$
$$I_1 230\Omega + 140V = \emptyset$$
$$I_1 = -\frac{140V}{230\Omega} = -0.609\ A$$ reversed currents

$$I_2 = -\frac{100V + (-0.609A)(90\Omega)}{40\Omega} = -1.13\ A$$

$$I_3 = -0.609A - 1.13A = -1.74\ A$$

VOLTAGE DROPS: $V_{R_1} = I_1 R_1 = (0.609A)(50\Omega) = 30.45V$

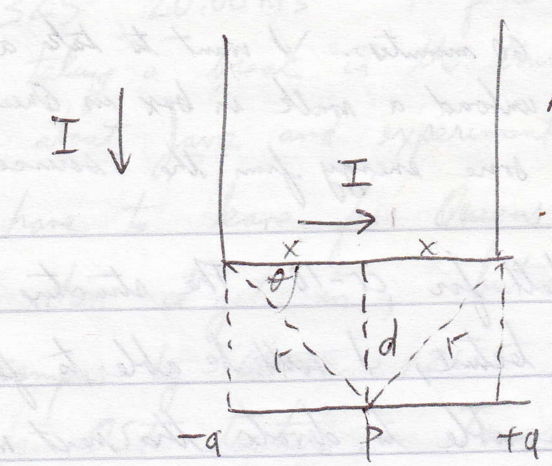
$V_{R_2} = I_2 R_2 = (1.13A)(80\Omega) = 90.4V$

$V_{R_3} = I_3 R_3 = (1.74A)(40\Omega) = 69.6V$

$V_{R_3} = V_a - V_{R_1}$

$V_{R_3} = V_b - V_{R_2}$

VERIFIES IT



$$r = \sqrt{x^2 + d^2}$$

$$\tan\theta = \frac{-d}{x}$$

$$x = -d\cot\theta = -d\,\frac{x}{-d}$$
$$= -d\,\frac{\cos\theta}{\sin\theta}$$

$$\sin\theta = \frac{-d}{r}$$

How to eliminate θ?

$$r = -d\csc\theta \qquad dx = d\csc^2\theta\,d\theta$$

$$\csc\theta = \frac{r}{-d} = \frac{\sqrt{x^2+d^2}}{-d} \qquad \csc\theta = \frac{1}{\sin\theta}$$

$$d\vec{B} = \frac{\mu_0 I}{4\pi}\,\frac{dx\sin\theta}{r^2} = \frac{\mu_0 I}{4\pi}\,\frac{\frac{d}{\sin^2\theta}\,d\theta\,\sin\theta}{(x^2+d^2)}$$

$$d\vec{B} = \frac{\mu_0 I}{4\pi}\int\frac{d\,d\theta}{\sin\theta(x^2+d^2)} = \frac{\mu_0 I d}{4\pi}\int\frac{dr\,d\theta}{-d(x^2+d^2)}$$

$$dB = \frac{\mu_0 I d}{4\pi}\,\frac{d\theta}{(x^2+d^2)}$$

This is getting nowhere fast. I can wait until tomorrow's lecture. Now I will piss and then review my cogitations. If the delivery truck does not arrive soon, I will doze off. Tonight, after OST lecture I think I will just relax. next section: 666

666

326 22:40hrs Jim Lawaich, instructor OST, told the class that my translator was on the verge of being an actual compiler, that it was sophisticated and performed its tasks seamlessly. He does not expect that kind of work, but I think he has gained some respect for me, as I have for myself, in the process.

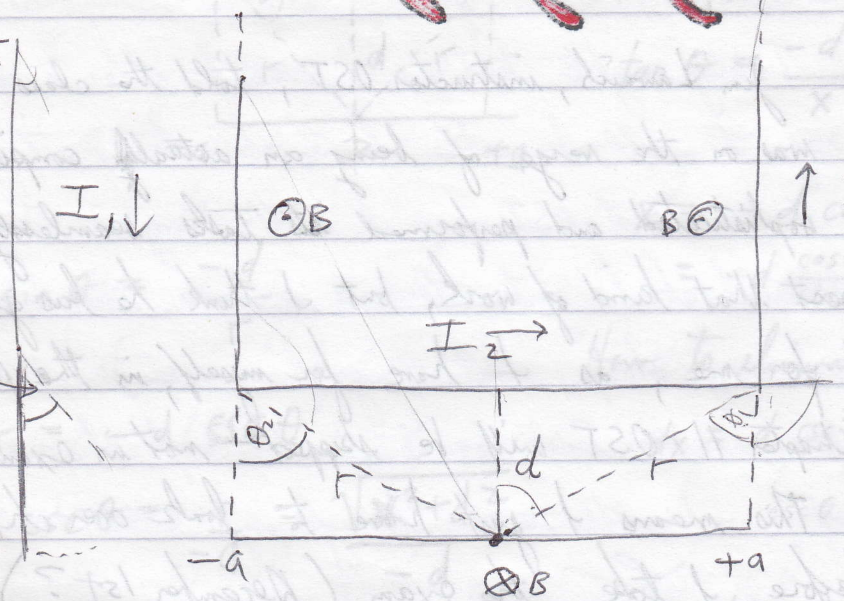
23:45hrs. Chapter 11 OST will be skipped - not in exam 2 nor final. This means I just have to look over ch6 to 10 inclusive before I take the exam (December 1st?).

1999 327 Tu 23 November 00:00 hrs

A few minutes before the OST lecture, I went into the Physics lab and looked at the solution to the problem covered on pages 190, 191, 192, 193, 194, and 212. My problem was not what I thought it was, but something more fundamental. Look at the "vertical currents" on page 212. $d\vec{s}$ is not parallel to the direction $\hat{r}$! Those two currents must be considered! There is no need to do the calculus over again. Apply the formula (derived with calculus) for computing/calculating magnetic field on a thin, straight current-carrying conductor:

$B = \frac{\mu_0 I}{4\pi a}(\cos\theta_1 - \cos\theta_2)$ for each current (line)!

666



label directions of each B (thumb in direction of current, curl fingers around current → right hand : $\odot$ out $\otimes$ in)

1 add subscripts to currents $I_1 = I_2 = I_3 = I$

I_3 is in infinite line $\theta_1 = \cancel{90}\, 0^\circ$, $\theta_2 = \dfrac{+d}{\sqrt{a^2+d^2}}$

(distance from current I_1 to point P is a)

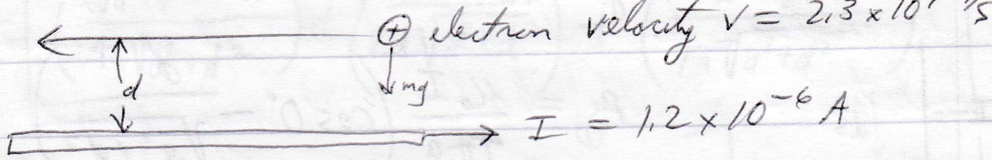
$$\therefore B_1 = \frac{\mu_0 I}{4\pi a}\left(\cos 0 - \frac{d}{\sqrt{a^2+d^2}}\right) = \frac{\mu_0 I}{4\pi a}\left(1 - \frac{d}{\sqrt{a^2+d^2}}\right)$$

$$B_2 = \frac{\mu_0 I}{4\pi d}\left(\frac{a}{\sqrt{a^2+d^2}} + \frac{a}{\sqrt{a^2+d^2}}\right) = \frac{\mu_0 I}{2\pi d}\left(\frac{a}{\sqrt{a^2+d^2}}\right)$$

$$B_3 = \frac{\mu_0 I}{4\pi a}\left(\frac{-d}{\sqrt{d^2+a^2}} - \cos 180^\circ\right) = \frac{\mu_0 I}{4\pi a}\left(1 - \frac{a}{\sqrt{d^2+a^2}}\right)$$

Then we add those 3 $B_1 + B_2 + B_3 = B$

I will redo this problem again until it is clear. First, here is some slightly different notation for the problem I solved on page 185.



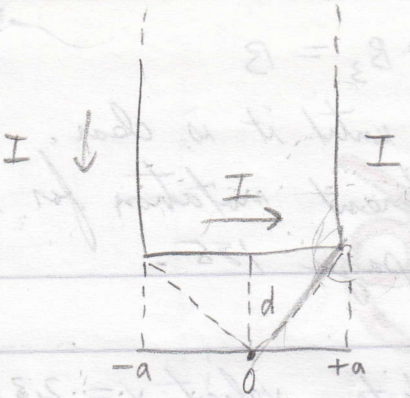
$$B = \frac{\mu_0 I}{2\pi d} \; : \; mg(-\vec{j}) + qv(-\vec{i}) \times \frac{\mu_0 I}{4\pi d} = \emptyset$$

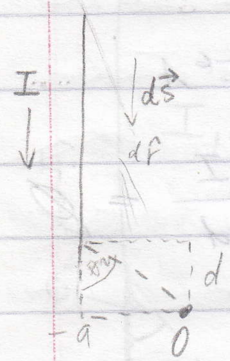
negative y direction

negative x direction

$$\underbrace{mg = qvB \qquad B = \frac{mg}{qv}}_{} = \frac{\mu_0 I}{2\pi d}$$

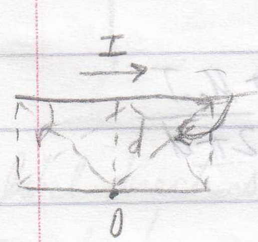
$$d = \frac{\mu_0 I}{2\pi B} = \frac{\mu_0 I q v}{2\pi mg}$$





① $$B_{①} = \frac{\mu_0 I}{4\pi a}\left(\cos 0^\circ - \frac{d}{\sqrt{a^2+d^2}}\right)$$

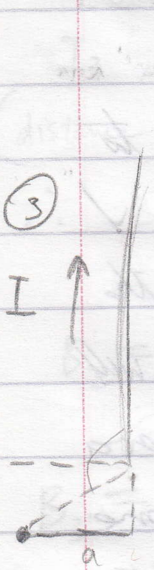
$$B_{①} = \frac{\mu_0 I}{4\pi a}\left(1 - \frac{d}{\sqrt{a^2+d^2}}\right)$$



② $$B_{②} = \frac{\mu_0 I}{4\pi d}\left(\frac{a}{\sqrt{a^2+d^2}} + \left(\cos 180^\circ - \theta_1\right)\right)$$

$$= \frac{\mu_0 I}{4\pi d}\left(\frac{a}{\sqrt{a^2+d^2}} + \frac{a}{\sqrt{a^2+d^2}}\right)$$

$$= \frac{\mu_0 I}{2\pi d}\left(\frac{a}{\sqrt{a^2+d^2}}\right)$$



③ $$B_{③} = \frac{\mu_0 I}{4\pi a}\left(-\cos(180 - \theta_1) - \cos 180^\circ\right)$$

$$= \frac{\mu_0 I}{4\pi a}\left(-\frac{d}{\sqrt{a^2+d^2}} + 1\right)$$

$$B = B_1 + B_2 + B_3$$

$$B = \frac{\mu_0 I}{\pi}\left[\left(\frac{1}{4a} - \frac{d}{4a\sqrt{a^2+d^2}}\right) + \left(\frac{a}{2d\sqrt{a^2+d^2}}\right) + \left(\frac{-d}{4a\sqrt{a^2+d^2}} + \frac{1}{4a}\right)\right]$$

$$= \frac{\mu_0 I}{\pi}\left[\left(\frac{\sqrt{a^2+d^2}-d}{4a\sqrt{a^2+d^2}}\right) + \left(\frac{a}{2d\sqrt{a^2+d^2}}\right) + \left(\frac{-d+\sqrt{a^2+d^2}}{4a\sqrt{a^2+d^2}}\right)\right]$$

$$= \frac{\mu_0 I}{\pi}\left[-\left(\frac{-2d+\sqrt{a^2+d^2}}{4a\sqrt{a^2+d^2}}\right) + \frac{a}{2d\sqrt{a^2+d^2}}\right]$$

$$= \frac{\mu_0 I}{\pi}\left(\frac{-2d^2+d\sqrt{a^2+d^2}+2a^2}{4ad\sqrt{a^2+d^2}}\right)$$

$$= \frac{\mu_0 I\left(-d^2+d\sqrt{a^2+d^2}+a^2\right)}{2\pi ad\sqrt{a^2+d^2}}$$

negatives screwered up?

328 19:00hrs Bad news: I received a letter from Rutgers informing me that they have not yet received my high school transcript from Christian Brothers Academy. Rutgers lost it, and they will not process my application until they "receive it". I was furious. I have been on-line writing letters (email) for the past 4 hours. I sent verbalizations to Kathleen Lambertson DVR, to Rutgers, and to CBA. I can do nothing about until Monday, when I will drive to CBA, pick up a transcript copy, and then drive to Piscataway to hand deliver it to Admissions.

I was going to complete the cr-10 assignment this evening, but I just got a call from old buddy Jason Iverson. We are going to meet for coffee in an hour. I may work on cr-10 after 23:00 hrs.

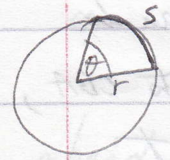
I have a feeling everything just may work out. Once I get this "missing high school credentials" taken care of, things should start happening. Lo, dinner, shower, coffee with JI, South Park?, cr 10 ... tomorrow TRIGONOMETRY session with nephew ... Thanksgiving dinner ... Soylent Green, Demolition Man ... Friday work, Saturday work. EVENINGS: PHYSICS.

Existence is a problem.

223

1999 330 Fr 26 November 00:16hr

I finished cr-10 this morning / this afternoon while my nephew read Cyberia. He witnessed me at work. I was also ~~able~~ able to review my "Mathematics 2000" notes (see intro to logbook #61). He took notes as I drew upon a portable blackboard such useful information as:

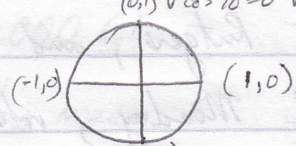


$s = r\theta$

$\theta = \frac{s}{r}$

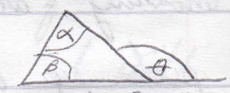
$\cos 180 = -1$
$\sin 180 = 0$

$(0,1)$ $\cos 90 = 0$, $\sin 90 = 0$



$\cos \emptyset = 1$, $\sin \emptyset = 0$

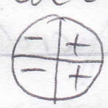
$\cos 270 = 0$
$\sin 270 = -1$



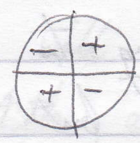
$\alpha + \beta = \theta$

$\sin\theta$

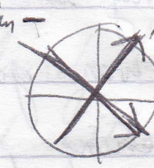
$\cos\theta$



$\tan\theta$



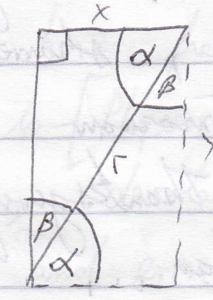
tan − tan +



$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$ $\tan\theta = \text{slope} = \frac{\Delta y}{\Delta x}$

The fact that ——— is $180° = \pi$,
◯ is $360° = 2\pi$, ...

"The sine of an angle equals the cosine of its complementary angle."



$\sin\alpha = \frac{y}{r} = \cos\beta$

$\cos\alpha = \frac{x}{r} = \sin\beta$

$\tan\alpha = \frac{y}{x} = \cot\beta$

Reference Angles:

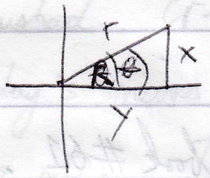
Quadrant	Relationship
I	$R = \theta$
II	$R = 180° - \theta$
III	$R = \theta - 180°$
IV	$R = 360° - \theta$

$\sin 0° = 0$, $\sin 90° = 1$, $\sin 180° = 0$, $\sin 270° = -1$

$\sin(90° - \theta) = \cos\theta$	$\cos(90° - \theta) = \sin\theta$
$\sin(90° + \theta) = \cos\theta$	$\cos(90° + \theta) = -\sin\theta$
$\sin(180° - \theta) = \sin\theta$	$\cos(180° - \theta) = -\cos\theta$
$\sin(180° + \theta) = -\sin\theta$	$\cos(180° + \theta) = -\cos\theta$
$\sin(270° - \theta) = -\cos\theta$	$\cos(270° - \theta) = -\sin\theta$
$\sin(270° + \theta) = -\cos\theta$	$\cos(270° + \theta) = \sin\theta$
$\sin(360 - \theta) = -\sin\theta$	$\cos(360° - \theta) = \cos\theta$

$\cos 0 = 1$, $\cos 90° = 0$, $\cos 180° = -1$, $\cos 270° = 0$

I

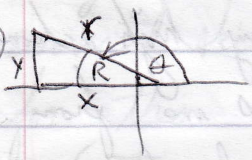


$$\sin\theta = \frac{y}{r} = \cancel{\cos R}$$

$$\cos\theta = \frac{x}{r} \quad \cancel{\cos R}$$

$$\tan\theta = \frac{y}{x}$$

II

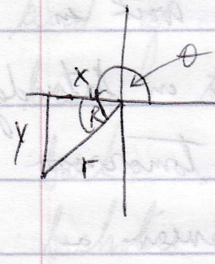


$$\sin\theta = \frac{y}{\cancel{r}} = +\sin R$$

$$\cos\theta = \frac{-x}{r} = -\cos R$$

$$\tan\theta = \frac{y}{-x} = -\tan R$$

III

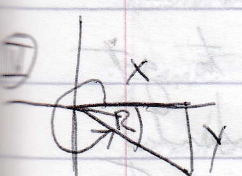


$$\sin\theta = \frac{-y}{r} = -\sin R$$

$$\cos\theta = \frac{-x}{r} = -\cos R$$

$$\tan\theta = -y/-x = \tan R$$

IV



$\sin\theta = \frac{-y}{r} = -\sin R$, $\cos\theta = \frac{x}{r} = \cos R$, $\tan\theta = \frac{-y}{x} = -\tan R$

My case could be documented as proof of the benefits of alternative forms of REHABILITATION. Locking "fallen angels" in hell is not going to rehabilitate. It may aggravate the situation.

Do I profess to offer grammar and mathematics and technical training to enthusiastic prisoners of the state? Would this not waste much time and money? Difficult situation, yes.

My cousin Eric has got nerve. He asks me how did I manage to get the State to pay for my education. Did I have to first proove myself to be a "burden on society" via a trip to the county jail? My cousin Eric remains ignorant of his insult. He thinks I am using the system like "a nigger"; and yet he has had his world handed to him by his father, a man who can manipulate tax returns and borrow money from others to purchase realestate. Judge me as a nigger if you feel this will help you to get over the fact that my organism is undergoing training that will prepare it for an exciting career in the 21st century. It will not matter how the training was paid for.

I accept the State's help with open arms. I feel no shame or regret. I have been diagnosed as manic-depressive. This made me eligible for financial assistance.

There is no way around such attacks from petty minded family members. For a fallen member to bounce back so rapidly via the financial assistance upon the very entity that was the "enemy" in the first place is quite difficult for petty gossipers to swallow.

Nevertheless, this organism is being sponsored by the State of NJ DVR to study at the State U come January ... 2000 ...

The only document holding up the processing of my file is a missing transcript from high school Christian Brothers Academy. Tomorrow I am on a mission to resolve this hold up. I hope to have this all taken care of before Friday, December 3rd. I hope to be able to log on to Rutgers web site to see the changes reflected there by Thursday night December 2nd.

Hence, tomorrow is a big day, I am anxious to resolve this matter.

In less than one hour my Grandmother Weber and two aunts Nancy and Gail will be arriving to wait for my mother to return from work as they are going to see the Nutcracker in Princeton. I have my usual Sunday afternoon splitting headache. I will take asprin and shower.

333 16:00 hrs Everything has been taken care of, and I have been told by DVR to relax, that I deserve to relax after having pulled nothing but A's in every course taken at Brookdale over the past 2 years.

Official: DVR will grant me $1350.00 per semester for room ($330.00 per month) and $800 per semester for board ($200 per month for meal tickets). The only problem is that come May, I am not sure where I will live. How many credits could I carry during a compact summer session? I will cross that bridge when I come to it. I may have to live in the basement for a couple months... Who knows?

I am very happy about the swiftness in which I resolved this problem. Maybe I was a little overdramatic with my letter to CBA closing with "One of your more devoutly intellectual graduates, Mike Hentrich".
(Still a sick man). So what. I went a little psychotic on them goddammit... but I was calm, just a little dramatic and passionate. Disturbed? Very. So, day #333 of 1999 C.E. turned out great. Many other little events synchronized with the triumph: (1) This Perfect Day arrived from Kansas; I dropped it off Joe's along with (2) a gift of 3 months with earth link for iamjmm@earthlink.net (3) Confirmation with DVR that this man will MOST DEFINATELY be GOING to Rutgers in January

I really do not care about how the intellectual snobs at CBA see me. "How dare he say he is one of the more devoutly intellectual graduates?" He is 33 years old! (The age Christ was when crucified). Let them believe I am deluded and angry. The people that matter happen to be the people that believe in me most: New Jersey's Division of Vocational Rehabilitation.

Now they believe in Mike Hentrich. Mike Hentrich is no joke. Now, I will attend the OST lecture tonight, hand in "Neural Networks: The Relationship Between The Computer and The Brain", and then start preparing for exams.

After this week, although OST will be light (lite) both Physics II and Java will be at warp speed. When I receive my "transcript status" from Rutgers I will be able to plan...

333 18:05 hrs. I will head over to BCC early so as to print a copy of NNP.WPS. I guess it is all down hill from now until Christmas. I will keep my eyes open for a room in New Brunswick in the meantime. One more outburst about how I might appear to CBA faculty: a teacher who was a graduate ~~teacher~~ from CBA (now professor of English (college) told me I was the most well read student he ever blah blah.

From page 61 on in this logbook I have been focused on Physics ch 27, 28, 29, & 30. To ease my mind a little, I will talk myself through the exam before I pass out. This is also an experiment in keeping my head together. Yes, I am a complex man. I had to mentally sort this petty credit bullshit out in my HEAD before I could focus on the task at hand.

I will be thankful for the opportunity to study at Rutgers, and if I have to take a course again because of the politics, I will become more comfortable with the concepts the second time around. I will find part time work as a programmer by March 2000 — and I will be free to live from ROOM to ROOM.

Now, enough of that. All is well. Be gone suicidal tendencies. The first couple problems on the Physics exam will deal with Resistance — as in $R = \rho \frac{l}{A}$
Given ρ_c and ρ_i, where ~~Area and~~ lengths ~~as~~ are the same, the ratio is r_c / r_i because $\frac{A_c}{A_i} = \frac{\pi r_c^2}{\pi r_i^2}$.

Next, there will be a lightbulb with R watts connected to a ~~120~~ V volt battery. Resistance $R = V^2/P$ and a current of $\sqrt{\frac{P}{R}}$. How so $I^2 = \frac{P}{R} \Rightarrow P = I^2 R$

also $I^2 = \frac{P}{\frac{V^2}{P}} = \frac{P^2}{V^2} \Rightarrow I = \frac{P}{V}$ ~~that~~ no problems here

Then there will be a couple long problems dealing with a simple circuit and then a Kirchhoff circuit. I will review problems from homework, perhaps even doing them again. Next there is charging and discharging a capacitor. This should be no problems.

The last 5 are as follows:

⑥ I will be given $\vec{V} = (2\vec{i} + 4\vec{j} - 3\vec{K})\ \mathrm{m/s}$

$$\vec{E} = (3\vec{i} + 5\vec{j} - 7\vec{K})\ \mathrm{N/C}$$

$$\vec{B} = (3\vec{i} - 6\vec{j} + 1\vec{K})\ T$$

A proton is put into the field. I will be asked to find the forces. $F_e = qE$

For a proton,

$$F_e = (1.6 \times 10^{-19}\,C)(3\vec{i} + 5\vec{j} - 7\vec{K})\ \mathrm{N/C}$$
$$= (4.8\,\vec{i} + 8\,\vec{j} - 11.2\,\vec{K}) \times 10^{-19}\ N$$

$$F_B = q\vec{V} \times \vec{B} = 1.6 \times 10^{-19}\,C \begin{vmatrix} i & j & K \\ 2 & 4 & -3 \\ 3 & -6 & 1 \end{vmatrix} \frac{m}{s}\,T$$

$$T \to \frac{N}{C\frac{m}{s}}$$

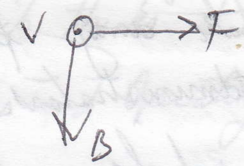
$$\therefore\ C\,T\frac{m}{s} = C\,\frac{m}{s}\,\frac{N}{C\frac{m}{s}} = N$$

$$|F_B| = 29.8$$

$$F_B = 1.6 \times 10^{-19}\,(-14\,\vec{i} - 11\,\vec{j} - 24\,\vec{K})\ N$$

$$\therefore\ F = F_e + F_B = (-17.6\,\vec{i} - 9.6\,\vec{j} - 27.2\,\vec{K}) \times 10^{-19}\ N$$

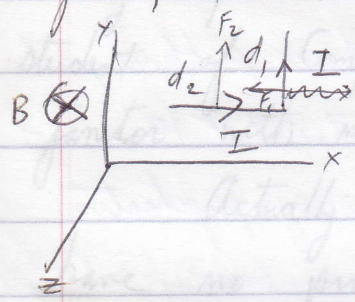
I think I will be able to "wing it". There will be a basic "Find $|F_B|$" where



$$|F_M| = qvB\sin\theta$$

if in components $|F_M| = \sqrt{(q(F_x))^2 + (q(F_y))^2 + (q(F_z))^2}$

Again, I can wing it if I must.



$F_B = I\vec{l} \times \vec{B}$

$$F_{B_1} = I\begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ 0 & d_1 & 0 \\ 0 & 0 & B \end{vmatrix}$$

$$F_{B_2} = I\begin{vmatrix} i & j & k \\ d_2 & 0 & 0 \\ 0 & 0 & B \end{vmatrix}$$

$F_{B_1} = Id_1B\,\vec{i}$

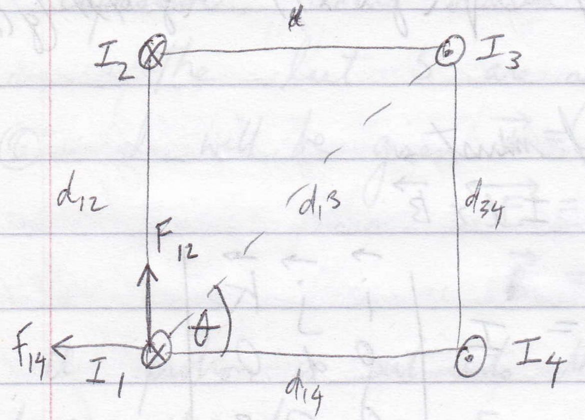
$F_{B_2} = Id_2B\,\vec{j}$ $\qquad F_B = IB(d_1\vec{i} + d_2\vec{j})$

$$F_B = \sqrt{(IBd_1)^2 + (IBd_2)^2}$$

$$\theta = \tan^{-1}\left(\frac{(IBd_2)}{(IBd_1)}\right)$$

23:00 The sleeping pills are kicking in. I will go over one more problem, but then I will read cogs before I pass out. My current mantra → "They cannot take my knowledge."

"They may be able to deny me credits, but they cannot take away from me my understanding". Business administrators may earn the big bucks, but I am a scholar, a programmer, a scientist, a philosopher.



$$d_{13} = \sqrt{(d_{14})^2 + (d_{34})^2}$$

$$F_{12} = \frac{\mu_0 I_1 I_2 l}{2\pi d_{12}} \quad \text{up} \quad \vec{j}$$

$$F_{14} = \frac{\mu_0 I_1 I_4 l}{2\pi d_{14}} \quad \text{left} \quad -\vec{i}$$

$$F_{13} = \frac{\mu_0 I_1 I_3 l}{2\pi d_{13}} \quad \text{get components}$$

$$\theta = \tan^{-1}\left(\frac{d_{34}}{d_{14}}\right) \qquad F_{13_x} = d_{13} \overset{\cos}{\cancel{\sin}}\,\theta \, \frac{\mu_0 I_1 I_3 l}{2\pi d_{13}}$$

$$F_{13_y} = d_{13} \sin\theta \, \frac{\mu_0 I_1 I_3 l}{2\pi d_{13}}$$

It is amazing what a difference an attitude makes. My head is not in the same place as most students. In fact, even Tom – the head of the Comp Sci department had.

suggested I go to another college beside Rutgers. This was his solution! Even Jim Lawrich thinks I would be wasting my time taking Data Structures and Operating Systems again.

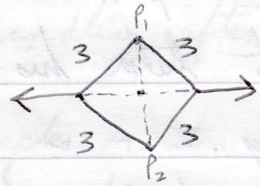
My strength is an ability to see the benefits in a situation that appears to be horrible by most standards.

What I am attempting is no less than to become totally impersonal. I would rather be a broke student of Computer Science and Mathematics than a janitor with mucho cash in the bank.

Actually, I enjoy learning so much that I have no problem being required to take more courses. Besides, I do suspect that I would learn a great deal more from Data Structures, OS Design, Discrete Structures I, and even Intro To Comp Sci precisely because I have taken the material before. THIS IS A LUXURY to be able to ~~take~~ be exposed to these concepts again. I will take it to a higher, deeper level.

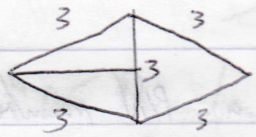
No one will be able to bring me down once I get started at Rutgers. Wherever I end up working, I will be a key player I hope. KNOWledge and Understanding are my goals, not wealth. This is my way of distracting myself from the disease we call life.

338 13:30hrs As soon as I got up, I began looking through old Physics books for clarification. My mistake was assuming that area does not change for the loop as the ends are pulled out.



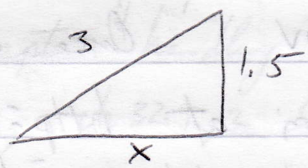
upon closer inspection, it is obvious that to pull outwards indefinitely would result in area = zero. So the area decreases. Originally, the distance between P_1 and P_2 is $\sqrt{3^2+3^2} = \sqrt{18}$ and half the diagonal (horizontal and vertical) is $\sqrt{18}/2$.

When distance P_1P_2 is 3m, the lengths of the sides of the diamond shaped loop are all still 3m;



but now the horizontal diagonal has increased proportionally to the decrease in the vertical diagonal.

Focusing on $\frac{1}{4}$ of the loop:



$x = \sqrt{3^2 - 1.5^2} = 2.598$

and the entire area of the loop is $4\left(\frac{1}{2}\right)(1.5)(X)\,m^2$, or, more simply $3x$, which is "the length of one diagonals times half the length of the other diagonal".

In the original loop, the area is $3^2 = 9$; in terms of the equal $\sqrt{18}$ m diagonals, the area can be written as $\frac{d_1 d_2}{2} = \frac{\sqrt{18}\cdot\sqrt{18}}{2} = \frac{18}{2} = 9$.

The new area is $7.794\,m^2$. Area decreases, Φ_m decreases, current is induced: $\mathcal{E} = \frac{d\Phi_m}{dt} = \frac{-B(A_f - A_i)}{t} = \frac{-0.1T(-1.21)}{0.1s} = 1.21$; $I = \frac{\mathcal{E}}{R} = \frac{1.21}{10} = .121\,A$